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THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

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Issue of Journal. Notice of the publication of each part of the Journal is contained in the first subsequent circular issued to the members, and in case of non-receipt, immediate intimation should be given to the Secretary. Duplicate copies of any parts can only be supplied to members on payment of 5s. each, plus postage; but cannot even then be had if the parts have been bound into volumes.

The Memorandum and Articles of Association, and the By-laws and Regulations of the Institution were published in the first issue of the Journal, and will in future be published in the first issue of every session.

Changes of Address. It is particularly requested that members notify the Secretary immediately, of any change of address; and members are also requested to advise the Parcel-Post Department as well as the Letter Office, of any temporary change of address, as, unless this is done, parcel-post packets will not be re-addressed; but will be returned to the offices of the Institution in London, thus incurring further expense for postage.

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All drawings, diagrams or other illustrations should be sent in a fit state for direct photographic reproduction.

All quotations, technical terms, and localisms should be indicated by means of inverted commas.

Foreign weights, measures, and costs should be given whenever possible; and also their English equivalents.

It is suggested that authors append as complete a bibliography of the subject treated as may be possible.

All papers and notes submitted to the Institution are supposed to be original communications unless distinctly stated to be otherwise, in which case the exact reference to the previous publication should be given.

Communications upon papers read at meetings, notices of personal movements, or other matter for which publication is desired in the next issue of the Journal, should be in the hands of the Editor on or before the last day of January, March, May or November as the case may be. Subsequent delivery may be too late for insertion.

The Library. In the full catalogue of the Library, published in our brochure of September, were included the titles of such papers in journals received as bear upon any subject within the purview of the Institution. Such titles are not included in the intermediate lists given in our several parts, where, as below, the journals received are acknowledged in single entries.

The attention of such of our members as are authors is directed to the absence of their works from the Library, (with some exceptions), and we shall be particularly thankful for gifts of treatises on special branches of technology, and for separate copies of papers contributed to other Institutions and to journals, either in past or future.

Additions to the Library.

Athenaeum. Subject Index to Periodicals, 1915. Science and Technology.

By Exchange.

Cassier's Engineering Monthly, vol. xlix, pts. 1, 2, 1916.

From Arthur W. Eastlake.

Day, D. T. Production of Petroleum, 1910. (from *Min. Res. U.S.*)

—— *Idem*, 1913.

From the author.

Gas & Oil Power, vol. xi, nos. 124, 125, 1916.

Imperial Institute, Bulletin, vol. xii, no. 1, 1914.

Institute of Mining and Metallurgy, Bulletin, nos. 136, 137.

Institution of Mining Engineers, Transactions, vol. l, pts. 2, 3, 1916.

——, Almanac, 1916.

Iron and Steel Institute, Journal, vol. xcii, 1916.

Kahncrete Engineering, vol. ii, no. 11, 1916.

Kindle, E. M. Notes on the Geology and Palaeontology of the Lower Saskatchewan River Valley. *Canada Geol. Surv., Mus. Bull.*, no. 21, 1915.

Malcolm, W. The Oil and Gas Fields of Ontario and Quebec. *Canada Geol. Surv. Mem.* no. 81, 1915.

By Exchange.

Natural Gas Association of America, Proceedings, vols. iii–vii, 1911–1915.

From Louis C. Sands.

Oil Age, vol. xi, no. 12 (1915): vol. xii, no. 1, 1916.

Oil and Colour Trades Journal, vol. xlviii, no. 897, 1915: vol. xlix, nos. 898–906, 1916.

Oil Exchange, Weekly Report, Jan. 6—Feb. 24, 1916.

By Exchange.

Oil News, nos. 161–168, 1916.

Petroleum Review, vols. xxxii, xxxiii, 1915.

Petroleum World, vol. xiii, nos. 1, 2, 1916.

From Sir Boverton Redwood.

Royal Society of Arts, Journal, vol. lxiv, nos. 3293–3301, 1916.

Society of Chemical Industry, Journal, vol. xxxiv, 1915: vol. xxxv, nos. 1–3, 1916.

Stansfield, A. Electrothermic Smelting of Iron Ores in Sweden. *Canada Dep. Mines, Mines Branch, Rep.* no. 344, 1915.

Stauffer, C. R. The Devonian of Southwestern Ontario. *Canada Geol. Surv., Mem.* no. 34, 1915.

Williams, M. Y. An Eurypterid Horizon in the Niagara Formation of Ontario. *Canada Geol. Surv., Mus. Bull.*, no. 20, 1915.

By Exchange.

The Boom Days of Beaumont [Texas]. 1901 ?

From W. Sutton.

Official Yearbook of the Scientific and Learned Societies of Great Britain and Ireland. 32nd annual issue. 1915.

Purchased.

Exchange List.

The following is the list of Institutions, etc., with whom we exchange publications: we shall be happy to extend it in suitable directions.

Athenæum Subject Index to Periodicals.
Australia, High Commissioner.

Canada, Department of Mines, Geological Survey.
" " " " Mines Branch.
Gas and Oil Power.
Imperial Institute.
India Geological Survey.
Institute of Chemistry.
Institution of Mining Engineers.
Institution of Mining and Metallurgy.
Iron and Steel Institute.
Junior Institute of Engineers.
Kahncrete Engineering.
Manchester Geological and Mining Society.
Midland Institute of Mining, Civil, and Mechanical Engineers.
Mining Institute of Scotland.
North of England Institute of Mining and Mechanical Engineers.
North Staffordshire Institute of Mining and Mechanical Engineers.
Oil Age.
Oil and Colour Trades Journal.
Oil Exchange.
Paint and Varnish Society.
Royal Society of Arts.
Society of Chemical Industry.
South Staffordshire and Warwickshire Institute of Mining Engineers.
United States Geological Survey.

The Journal is also forwarded to the British Museum, Copyright Department, and to the Patent Office Library.

Advertisements in the Journal. A limited number of advertisements of firms interested in the Petroleum Industry, may be inserted in the Journal. Application for terms, etc., should be made to the Secretary.

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PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

We have to sympathise with Dr. T. O. Bosworth, on the loss of his two brothers in the service of their country.

Mr. J. T. Armstrong is requested to favour the Secretary with his present address.

Capt. Arthur T. Beazley who returned from California some time ago, and has been at the Front, is now engaged at the Ministry of Munitions.

Mr. J. R. Bourchier has been gazetted 2nd Lieut. A.S.C.

Prof. Cadman has received the honour of the most distinguished Order of St. Michael and St. George.

Mr. L. de Florez left London for New York in January.

Mr. T. R. H. Garrett has received a commission in the R.N.V.R. (Air Service).

Mr. F. A. Holiday is leaving for South America early in March.

Capt. R. H. MacKenzie, R.E., has been awarded the Military Cross.

Mr. G. W. Mancell returned from Russia in January.

Mr. L. Owen is 2nd Lieut. in the Royal Engineers.

Mr. A. F. Strickland is a Petty Officer in the R.N.V.R.

DINNER AND LUNCH CLUB IN CONNECTION WITH THE INSTITUTION.

The object of this Club is to enable members to dine together before each Meeting, and to lunch together a few days later, so that they may thus have the opportunity of informally discussing various subjects brought to their notice.

Members are entitled to introduce guests, on giving due notice to the Hon. Secretary of the Club.

As each person present pays for his repast, the Club subscription is a nominal one, only intended to defray the cost of printing and postage. It is at present fixed at five shillings per annum. More than thirty members have already joined the Club.

Sir Boverton Redwood is the Chairman, and Mr. Arthur W. Eastlake the Vice-Chairman, of the Club.

Mr. Ashley Carter, of Dashwood House, New Broad Street, E.C., kindly acts as Hon. Secretary to the Club.

EDITORIAL.

Waste. Whilst everybody is preaching economy (for others to practise), and Governments are contemplating or carrying out various measures in restriction of what is regarded as waste, our concern as an Institution is necessarily concentrated solely upon petroleum and its products as a subject for consideration in this respect.

We referred in our last issue to the protection of oil-bearing rocks from the dispersive action of percolating water, introduced by boring operations. In some regions compulsory plugging of abandoned wells is in force, although where sand is prescribed for the purpose, the remedy is worse than the disease, perpetuating the mischief which caving clays would automatically terminate in the course of time. The introduction of the system of loading the flush-water with mud, to seal the pores of water-charged beds, is a step in the right direction, except in the case of testing a new area, or beds more deeply seated than those known to be productive of oil.

It is not to be supposed that the last word has been uttered in respect of improvements in the methods of shutting off water, or in control of oil or gas when encountered under exceptional pressure, but it is clearly the duty of all engaged in drilling operations to have the best of known appliances at hand in preparation for such discharges, whether anticipated or unforeseen.

The temporary storage of crude oil, its protection from loss of volatile constituents (or the collection and utilisation of these, whether condensible or permanently gaseous), judicious treatment in the still or at later stages, the separation of the most useful constituents (as judged by the special requirements of the times), so that the greatest possible advantage may be secured from the natural complex of different hydrocarbons, and, lastly, the most economical systems of transport, distribution and ultimate utilisation, are all matters on which much improvement is yet possible, and which might each furnish the topic for a valuable paper and useful discussion, as some have already done in these pages and elsewhere.

Some of the single items in this summary involve indeed a wide range of distinct subjects, requiring special technical knowledge for their effective handling. Thus, a practical surrogate for sulphuric acid for washing is at present a desideratum, particularly as, apart

from cost and scarcity, there is rather more than a suspicion that, in some oils, its action produces objectionable sulphur-compounds, leaving the oil worse for the process.

Adequate solution of this and many kindred problems would obviate, if not waste of oil, the ineffectual use of materials and time, whilst every improvement in plant or process is of direct benefit to producers, distributors and consumers.

It has been suggested that valuable ideas not infrequently occur to minds trained in other studies than those directly connected with the new-born conception, and thus often pass into oblivion, from their authors' inability to carry them to experimental confirmation personally or by skilled assistance. The proverbial perspicacity of the onlooker may be a law in invention, as in other matters, and imagination untrammelled by experience may reach a goal unattainable without such freedom. The loss of these potential flashes of genius, birth-strangled babes of the mind, is a less tangible, but not less real, source of waste than those already mentioned, and the crux of the problem which this waste presents is, how to bring these crude conceptions into the crucible of expert investigation.

In referring to the reported discovery of a cheap adjunct, alleged to increase the motive power of petrol to an extent suggested as approaching 50 per cent., a contemporary urges that our Institution might make arrangements for the testing of substances, mechanisms, or other embodiments of inventive genius, connected with petroleum or kindred subjects, and not previously submitted to conclusive trial.

The commercial aspect of invention has to be considered in this proposition. Plausible suggestions might cause the expenditure of much time, energy, and material in proving them worthless or financially impracticable, and for really valuable ideas, their originators would expect more than the barren honour of parentage, whilst it is needless to point out that the Institution could take no part in the commercial results.

It remains to be seen whether these and other practical difficulties can be surmounted, the most serious being the financial aspect for our very juvenile corporation, and meanwhile the conception of such an extension of the educational functions of the Institution is submitted for the consideration of our members and other readers.

Tenth General Meeting.

A meeting of the Institution of Petroleum Technologists was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C., on Tuesday evening, 21st December, 1915, Sir Boverton Redwood, Bart., D.Sc., F.R.S.E. (President), in the Chair.

The Members of Council present were Mr. Arthur W. Eastlake, Dr. F. Mollwo Perkin and Mr. T. C. Palmer. Messages of regret for unavoidable absence were sent by Professor John Cadman and Sir Thomas H. Holland.

The President, before calling upon Mr. Holiday to read his paper, announced that the fifth number of the Institution's Journal, commencing the second volume, had been passed for press, and the printers hoped to be able to deliver it soon after Christmas. It contained, besides 16 pages of preliminary matter, 84 pages of text, with 16 illustrations.

The following paper was then read, illustrated by many lantern slides:—

The Uralsk Province and its Oilfields.

By F. A. Holiday, A.R.C.Sc., F.G.S., M.A.I.M.E., *Member*.

In the last few years, a good deal of interest has been aroused in an oil-bearing region, which, it is widely believed, is destined to play an important part in supplying the future demands of the Russian Empire for petroleum and its products.

For some time past travellers and explorers have reported exudations of oil and gas, occurrences of asphalt, and other surface indications of petroleum, at various points in the tract known as the Kirghiz Steppes. These points have been located on maps, some fairly accurately, others far from correctly. This is partly due to the rarity, over a great part of the area, of landmarks of any kind, with regard to which the position of the observed occurrences may be described, and partly to the fact that the available maps of the region were not very accurate. In some parts of the steppe, the only possible points of reference are the tombs erected by the nomadic Kirghiz to their deceased saints, and a good deal of doubt seems to have existed about the correct naming of these places, adding to the difficulties of the explorers and cartographers.

Many of these localities have received more or less study from geologists and other experts, often by means of shallow pits and borings, since visible indications of the geological structure are as

scanty as the landmarks. Various hypotheses as to the structure and the age of the beds have been advanced, in some cases backed by insufficient evidence, or by no evidence at all: and with the exception of a few areas which have been carefully investigated for commercial purposes, the geology of the region is little known as yet, whilst, owing to its great area, its wildness, and the sparseness of the population, it is probable that there are within its bounds indications of petroleum which have not yet been recorded.

Although the phenomena observed, especially in the better known localities, fall naturally into certain groups, based largely on mutual proximity and other topographical considerations, it is difficult, until the structure of the region is better known, to divide it on scientific grounds, into separate areas or oilfields, as has been done, for instance, in the Apscheron peninsula (Baku). We are faced with similar difficulties in attempting to define the limits of this oil-bearing territory. An estimate of its area, made to-day, would considerably exceed one made a few years ago, on account of the gradual discovery of more seepages, but must in any case be somewhat arbitrary.

Roughly speaking, the reported signs of petroleum, shown on this map, lie between the 51st and the 46th parallels of north latitude, and the 49th and 58th of east longitude. It will be seen that they are distributed over a very large part of the Uralsk province. To get some sort of an idea of the extent of country involved, we may take a line from the point where the west boundary of the province reaches the Caspian shore, following this boundary northwards to the town of Alexandrovsk Gai, which lies just outside Uralsk, thence east to a point near the town of Temir, again south to Murtuk, and finally in a south-westerly direction, following more or less the course of the Emba river to the sea again, the southern boundary being, of course, the coast.

The area of this figure is, roughly speaking, some 60,000 sq. miles, somewhat greater than that of England and Wales. Evidences of oil are found all round, outside these limits, and there is marked on this map a place called Djusa, in Turgai province, which has attracted much attention of late, but as we are considering the Uralsk province particularly, we must draw the line somewhere.

In case these figures might lead astray persons of an enterprising and speculative disposition, let us emphasise the fact that we are not stating the dimensions of an oilfield, or of proven oil-bearing territory, but are merely noting that over this large area fairly frequent indications of petroleum occur.

Physical Features, Climate, etc.—The level of the Caspian Sea

is 84 feet below that of the Black Sea, and round its shores, also below sea-level, lies a zone of land, of greater or less width according to its inclination. By far the largest area of depression is that on the north, extending from the Volga to east of the Emba river, forming a belt of varying width. If a contour line be drawn, representing the datum line, ocean level, it will be seen that in general the part of this region north of lat. 50° is above, whilst that south of the 50° line is below it. In the eastern part of the area, however, where the ground rises more rapidly, this contour line turns sharply southwards.

Travelling inland from the shore of the Caspian Sea, a great plain is traversed, whose gentle rise northward is imperceptible. This same gentle inclination of the plain continues southwards into the sea for some miles. The coast line is thus ill defined, and consists of a belt of swampy land. Differences of level of a few feet in the surface of the sea causes the water to advance or retreat for a considerable distance. There are, it is true, no tides in the Caspian, but differences of level of four feet, and sometimes, it is stated, even of eight feet, are caused by the winds piling up the water in one direction or another, while other causes are differences of barometric pressure in the N. and S. ends of the Caspian, and also any conditions which disturb the equilibrium normally existing between loss by evaporation on the one hand, and the supply of water from rivers and rain on the other.

Returning to the land, the plain is, generally speaking, absolutely flat and featureless, every hollow having been filled, and every prominence covered by the deposits of the Caspian Sea, during the period, geologically very recent, during which it extended far beyond its present limits. The soil is formed of sandy clays, or clayey sands, often heavily charged with salt. In other places are encountered considerable accumulations of loose sand, due to the action of the wind. Other areas are swampy, while there are a number of salt lakes, many of which are dried up by the heat of summer, when their beds are covered with a glistening white deposit of salt.

Frequently one may travel for miles without ever meeting the smallest landmark of any kind, except here and there a tomb erected by the Kirghiz nomads.

Trees are entirely wanting on these steppes, excepting where they have been planted by the sides of rivers. Scanty grass and a small shrub is to be found over a great part of the area, on which the herds of the Kirghiz feed as they travel. In favoured spots, near streams and fresh water, there is greater abundance of herbage,

whilst other places where excess of salt, or of loose sand, renders vegetable life impossible, are quite desert.

Further northward and north-eastward with increase of elevation the land becomes a plateau through which the rivers flow in deep gorges. The northern boundary of this tract of country is formed by the highlands near the Ural River, belonging to the Obschii Syrt. In the north-east, and east, highlands rise gradually to the Mugodjar hills, and in the south-east corner, the boundary is the elevated Ust-Urt plateau. On the west, the plain stretches into the steppes of European Russia.

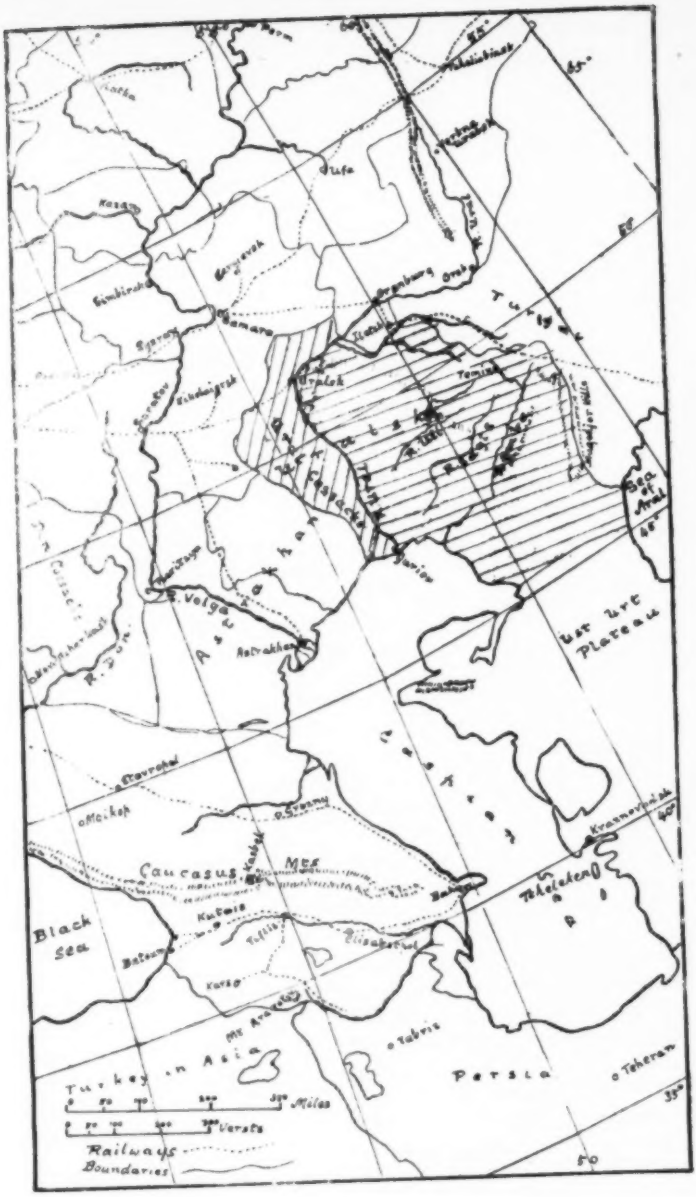
Thus in the east and north-east the highland is nearer the sea than in the west. The town of Uilsk is considerably higher than Uralsk, although the latter lies considerably to the north-west of it, and the general slope of the whole region appears to be from north-east down towards south-west.

The principal river in the Uralsk province is of course the river Ural, which rising in the Ural mountains in Orenburg, and travelling a little south of westward from the city of Orenburg to Uralsk, turns and flows practically due south to the Caspian Sea, into which it empties itself at Guriev.

Next in importance is the river Emba, in the east, which rises near the Mugodjar hills, and receiving as tributaries the Temir, and some other unimportant streams, divides some 50 versts from the Caspian, the north or principal branch reaching the sea at the fishing village of Jila Cosa. It is a shallow river, and in some summers does not discharge directly into the sea, losing itself in swampy ground. Between the Ural and the Emba, lie the rivers Uil and Sagiz, which have their sources in the highland to the N.E. of the petroliferous area. The former disappears among the sands of Taisuekan, and some small lakes near Kizil Kuga Bazar, and the latter in the lowlands near the Caspian to the north of Rakusha.

There are other unimportant rivers which all terminate in the same vague way.

West of Guriev in the Cossack lands, a few small streams find their way into the Caspian, one in particular, the Bolshoi Baksa, which is really a branch of the Ural, passes the village of Novo-Bogatinsk, which is getting known as a probable oil-centre, and furnishes good water, with fresh-water fishes, as far as a dam near the village. Sometimes it runs dry, but water is obtained by making holes in its sandy bed. Below this dam, it, as well as the other streams between it and Guriev are apt to be brackish. Their degree of salinity, small at any time, is variable; when they are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bringing down but little water, they are invaded by the Caspian Sea. The Caspian waters, however, are only moderately saline, especially in the shallow northern parts, which are much influenced by the great volume of water discharged by the Volga and the Ural. Although the streams between Guriev and Novo-Bogatinsk are small, their importance is enhanced by the fact that they occur in a district promising to prove rich in oil.

As the climate of this region is quite continental, a considerable range of temperature is experienced in the course of the year, the summer and winter temperatures being respectively higher and lower than the mean temperature of its latitude for these seasons.

While the isothermal line, or line of equal temperature for January which passes through Guriev, turns sharply northward, to the west of Russia, and passes through Petrograd, the eastward extension of the same line, which represents 17° F., or 15° of frost passes through Pekin and the north of Japan.

The July isotherm through Guriev represents about 77° F. The mean annual temperature is somewhere near 46° F. at Guriev; at Uralsk it is about 42° F. The extremes reached of course greatly exceed these figures both in summer and winter. By April the Guriev isotherm passes through the south of England, and in the summer through the extreme south of Europe, and points on the north coast of Africa, whilst it does not move northwards again till October. There is thus a wide range of temperature, not only during the year, but also in the course of twenty-four hours, for often out on the steppes cold nights follow the hottest days in summer.

This region forms the north-western extremity of the great tract of low rainfall which stretches for some distance through Central Asia. At Guriev, the rainfall is only some 17 cm. annually, but at Uralsk it is about 34 cm., the seasons of greatest rainfall at these two places being the spring and the summer respectively. In the Guriev district, there is also a good deal of rain in the autumn.

There is a great deal of wind on the steppes, the prevailing winds coming from the north or north-east in winter, and the south and south-west in summer.

Taking it all round, however, the climate is not a bad one, and many Europeans live at Guriev and the adjoining centres in comparative comfort all the year round, with the exception, perhaps, of a few of the hottest days in the summer.

Navigation in the North Caspian and the Volga is closed by frost about the middle of November: to reopen in May.

Inhabitants, Towns, etc.

The Uralsk province has a total area of about 125,000 sq. miles (284,400 sq. versts), and is about 3 per cent. larger than the British Isles. As the map shows it is divided into two parts by the Ural river. All the land on the western side of the river, together with a narrow strip on the eastern side, is the territory of the Ural Cossacks; it amounts to some 27,250 sq. miles, and is nearly as big as Scotland. The land on the east belongs to the Crown. The population of this great province was estimated a few years ago at about 750,000 souls, of whom nearly two-thirds were described as nomadic.

At this rate the "elbow-room" works out at about 106 acres per head of the population. Other estimates place the population rather higher, but it is impossible to get the correct figures for the wandering Kirghiz. The cattle of various kinds amounted at the same estimate to some 4,000,000, including horses, 370,000; camels, 188,000; oxen, 780,000; sheep, 2,470,000, etc. Occasional plagues make great havoc of the cattle.

The original inhabitants of this region are the Kirghiz, an essentially nomadic race, who travel with their herds of camels, horses, sheep and goats, which manage to subsist on the scanty grass covering the steppes.

These people live in dome-shaped tents, made of a light wooden frame covered with camel-skins, or other suitable material, and having a circular hole at the top, which can be closed if desired. The tents, which look very rough, are surprisingly comfortable, affording a considerable amount of shelter from the blazing sun, as well as from the cold winds. The floor is partly covered with skins, rugs, and sometimes with beautiful oriental carpets, but part of it is left bare, and on this the fire is made. The tents are easily erected and taken down, and with two or three trunks, containing a few simple household utensils, form the whole luggage of a Kirghiz family. The typical mode of transport is of course on the camel's back, but in these days many Kirghiz have carts.

Water is scarce in these steppes, but the Kirghiz have nevertheless discovered many spots where it may be had free, or nearly free, from salt, and here they have dug wells, which enable them to supply their needs when travelling. As the hot weather dries up the lower part of the steppe, they move northward, to places where there is a better supply of water and pasture.

The entire absence of trees causes the fuel problem to be somewhat acute, and though, like the Arabs, they collect the dried manure of their herds for cooking and heating purposes, wood is greatly

prized by them. The advent of western civilisation furnished them with a certain amount of firewood, in the shape of telegraph poles, and the stakes used to mark out claims. They have, however, learnt by now to respect the former, though not, in most cases, the latter.

Far out in the steppes one meets with groups of Kirghiz who are still very primitive, but contact with the Russians has altered those who approach the inhabited districts. They earn money, or its equivalent in goods, by trade in cattle and fish, by transporting goods for the Oil Companies, and by manual labour, and thus raise their standard of living. Many of them settle in the villages, especially in the winter, though they mostly wander in summer.

As a race they are not particularly strong or energetic, but intelligent. Like many Asiatics they take kindly to study, and those that adopt the more settled life and attend schools, etc., make good pupils, but if they try to continue their higher education in Russian towns, are liable to break down with pulmonary consumption, for they are essentially a nomadic, open-air race. Even in their native steppes they are frequently attacked by a terrible plague, which attacks the lungs, is exceedingly epidemic, and always rapidly fatal. The Cossacks and Europeans are not nearly so susceptible to this malady, although not altogether immune, but when the plague is about, the wandering groups of Kirghiz are not allowed to approach the towns, so that the white people are seldom attacked by it.

Regarded as workmen for the oilfields, the Kirghiz, although as already said, somewhat lacking in strength and energy, are, on the other hand, sober and orderly. One is never sure of keeping a Kirghiz workman, as he generally has a family and some cattle wandering about somewhere, and is liable to go off and join them at short notice.

The ruling race in this country are of course the Ural Cossacks. They are a military race, from their boyhood up, and have numerous privileges in return for their services. On their own lands the Cossacks have exclusive rights to all vegetable produce, and to all grazing, all game, and all fish, and no one else has the right to use the rivers in any way without their permission, and they are very jealous of their privileges. The Ural river is a great source of wealth to them. It is abundantly stocked with fish, and great quantities of caviare are obtained, which forms a valuable export. In the fish-breeding season any sort of boating on the river is most strictly forbidden, and at one time this caused some difficulty to the oil companies at Guriev, who wanted to keep their communications open, across the Ural, with Dos-Sor, and their other properties on

the east side. At present there is a bridge on pontoons across the river.

The Cossacks are a sturdy race, and capable of making good workmen; they are however, as may be imagined, somewhat independent, and, before the edict abolishing the vodka monopoly, there was a great deal of insobriety in all the towns and villages.

The principal town of the whole region is Uralsk, with some 45,000 inhabitants: Cossacks and other Russians, Kirghiz and Tartars, are all to be found there. There are many good buildings, and fairly good hotel accommodation. The Governor of the Uralsk province resides there. All business connected with exploring and mining rights on the Cossack lands, West of the river Ural, must be conducted here with the Cossack authorities.

Along the Ural river, between Uralsk and Guriev, are a number of small towns, the chief being Lbishchensk (4,000 inhabitants) and Kalmikovsk (2,000 inhabitants).

Guriev, at the mouth of the Ural river, with 11,000 inhabitants, is the chief town after Uralsk. It has up to now served as the head-quarters of the various companies operating in the oilfields. As long as the Volga and the north of the Caspian Sea are open to navigation, it may be reached from Astrakhan by sea. Astrakhan itself is reached from the interior of Russia, either by railroad or by the excellent steamers running on the Volga. The service between Astrakhan and Guriev is performed by two companies, the Eastern (Vostotchni) and the Gurievski. The journey is accomplished under favourable conditions in 36 hours, though in bad weather, or if, as is often the case, heavy barges are towed behind the steamer, the voyage takes considerably longer. Up till two or three years ago the service was very bad, being performed by a couple of small boats, which, if the wind got rough, would put in to the shallows near the coast, and anchor in a few feet of water, but lately there has been much improvement.

The landing at Guriev is somewhat difficult on account of the extreme shallowness of the water, especially when the wind blows the sea away from the shore. Travellers leave the steamer in a tug, which takes them as far as possible. The final stage of the journey is made in carts, which drive out to meet the tugs, or barges, and take the passengers, sitting on their luggage, through the shallow water, to the shore.

If navigation is not open on the Caspian, the journey to Guriev must be made via Uralsk, which itself is reached from the interior by rail, after crossing the Volga by ferry at Saratov. Guriev is then reached by the road, which nearly follows the course of the

river Ural, with post horses and carts (or tarantasses), or if there is snow, with sledges. The distance by road is 330 miles, and there are 23 stations at the Cossack towns along the river, already referred to, at which horses are changed, sometimes with considerable delay. The journey is very uncomfortable, and its length depends on the ability of the traveller to endure the joltings and fatigue without resting It is possible to travel night and day as horses and drivers are continually changed, but four or five days are frequently taken over the journey. With a good automobile, and with fairly dry weather, this road may be covered in less than two days, the journey from Saratov to Guriev via Uralsk, under these conditions, being quicker than that via Astrakhan.

The steamboat companies are not recognised as mail carriers, and letters posted in Guriev for Astrakhan are taken by the postchaise right up to Uralsk or down again by rail to Astrakhan. This, the only route in winter, means great loss of time in summer.

In the spring of 1914, the Ural river overflowed its banks, and while part of the journey from Uralsk could be performed by road, crossing temporary lakes and streams on rafts; the lower country was completely flooded, and the last two days of the journey had to be performed in boats. As this inundation extended for some distance on either side of the river quite down to the sea, Guriev was an island for the time being. It should be pointed out that this state of things was altogether exceptional, nothing like it having been seen before by the living inhabitants of the country.

In the east of the province is the town of Temir, near the Orenburg-Tashkend railway. It may be reached by road, via Uilsk from Uralsk or Kalmikovsk. The roads are not made, but are only tracks across the steppe. On several of them there are small stations at which horses may be changed, but the accommodation on the others is inferior to that on the Uralsk-Guriev route.

Dos-Sor, at which there was no settlement a few years ago, now ranks as one of the towns of the province; there is of course no post road there, but the oil companies provide a few water-stations between Dos-Sor and Guriev, for their own traffic.

Besides the principal towns and villages, there are a few small settlements scattered about the steppe, some with a mixed population, and some inhabited by Kirghiz and Tartars only, with perhaps one Cossack, as the representative of the Government.

Petroleum Mining Claims.

Prospecting or exploration claims are called zaiavkas. The word zaiavka means declaration or testimony, but is also used to denote a claim or plot of land.

This territory is attached to the Astrakhan mining district, and is under the jurisdiction of the Southern Mining Department at Novotcherkask. Zaiavkas for oil prospecting are granted by the Department of Agriculture and State Domains, whose headquarters are at Samara; claims on the Cossack lands, west of the Ural river, are granted at Uralsk.

The prospector must declare that he has placed claim-posts in such and such places, stating accurately their position with regard to some definite point of reference.

Each claim-post is the centre of a zaiavka, which has an area of 37½ desiatines, or about 101 acres, and forms a square whose sides measure 800 sagens or 700 yards. The certificate gives the right to explore the ground in any manner, including drilling, for two years, before the end of which period allotments, or otvods, may be selected. Not more than 10 desiatines may be taken up in any one zaiavka, rather more than a quarter of the original prospecting claim: the remainder of the zaiavka reverts to the authorities, to deal with as they think fit.

When once an otvod is selected, the holders may keep it as long as they like, provided that they produce oil, on a yearly payment of R.20 per desiatine.

Zaiavka holders cannot market any oil they may produce, until they take out an otvod.

It is obvious that during the two years' tenure of a zaiavka, every effort must be made to obtain a knowledge of the structure of the ground, in order to select the otvods in the best possible position. In places where geological data can be obtained from a superficial examination, this may be comparatively easy, but unfortunately, over a great part of this region, such knowledge can only be obtained by digging pits, or by trial drilling, which require time and money.

In many cases the prospector, who has staked out his claims in a hurry, round a seepage (which is often the only indication of the underground conditions), in order to forestall possible rivals, is not the representative of a group who are in a position to carry out costly operations.

He, or his employers, may be obliged to look for capitalists or company promoters, who will be in a position to develop the property. Much time may elapse, and there is a danger that, by the time the zaiavkas are in the hands of those willing and able to develop them, the two years' tenure is drawing to a close, and finally the otvods may have to be selected before sufficient evidence has been obtained.

There has unfortunately been a great deal of wild speculation in the Ural region during the last few years.

Thousands upon thousands of zaiavkas have been taken up, sometimes in places where there appears to be no possible reason for their selection. In many cases they have been hawked about, no exploratory work proceeding in the meantime, and their value gradually decreasing, as the end of the two years' period drew nearer. An enormous amount of work has been thrown on the mining authorities, not only as regards the clerical labour involved in the granting of certificates, but also in the field, where their surveyors have had some difficulty in coping with their task. In some places trouble and confusion have occurred over the position of the claims; overlapping occurring, and this not necessarily through the deliberate "jumping" of claims.

For instance A, taking a certain Kirghiz tomb as his reference point, marks out a number of claims to the east of it. He then departs, and the Kirghiz promptly take his claim-posts for firewood. Soon afterwards B, starting from another tomb lying a few versts east of that of A, marks out claims to the west of it, and overlaps A's zaiavkas. Through inaccuracies in maps, or mistakes in naming, the tombs may be thought to be further apart than they really are, and A and B may meet later and compare plans, and honestly believe that they have not infringed on one another's rights. The geography of the country is getting better known now, but much confusion has arisen from these causes.

While much money has been wasted in rash speculation with zaiavkas on which never a stroke of work has been done, real hardship has been caused in other cases to genuine enterprises, which have been nipped in the bud, or held up, by the outbreak of war, and it is to be hoped that when peace is restored, the Russian authorities will deal with these cases in a liberal spirit.

Development.

Although special privileges, to encourage the commercial exploration of this country were granted as early as 1899, its development has only been begun within the last few years.

Firstly in 1899 exclusive rights to search for oil in six volosts (or districts) were granted to Lehmann and the heirs of Doppelmayer. These privileges were renewed several times until near the end of 1909. Several scientific men studied the field during this period, notably, Messrs. Lebedev and Nikitin. Towards the end of the period Mr. Stahkeev joined the other capitalists. A good deal of exploration work was done, especially at Iskene,

Dos-Sor, Karaton and Karatchungul. At Dos-Sor a number of wells were sunk by Messrs. Lehmann and Stahkeev, and some oil was obtained at moderate depths, but in the light of later work, it is evident that none of these wells were deep enough to thoroughly test the locality, a mistake often made in prospecting. At Iskene oil was found, though not in large quantities, at various depths—75 ft., 170 ft., 190 ft., 490 ft.

At Karaton oil was encountered at various depths, a number of small shows being found at from 30 ft.–60 ft., as well as at lower horizons. At Karatchungul several wells worthy of remark were drilled. In one, in particular, oil was struck at 143 ft., and spouted somewhat intermittently, 90,000 poods in three days, and continued to flow at intervals, for some time, giving, it is stated, some 300,000 poods. At this point gypsum was met with, followed by clay. But the most interesting point is that in another well, where oil was met at 37 ft. (200 poods a day), and at 126 ft. (130 poods a day), below the latter point a great thickness of gypsum and rock-salt was traversed, and at a depth of 1,000 ft., still in gypsum, evidences of petroleum were again encountered. Nevertheless the commercial development of the district was delayed. From the end of 1909 the concession was renewed until November 12th, 1912. An English Company, the Ural-Caspian Oil Corporation was formed, and took over all the privileges of the concession, to which two more volosts had been added, (giving the territory the well-known form which appears on the maps), these privileges including a valuable rebate of half the excise duty on refined oils, for the first eight million poods, this rebate holding good for five years from January, 1910. At five places however, Dos-Sor, Iskene, Makat, Karaton, and Karatchungul, a certain number of zaiavkas were reserved by the original concessionaires, their plots, and those of the Ural-Caspian Corporation alternating like the black and white squares on a chessboard. The new owners of the Concession had to get to work and choose their zaiavkas, before the end of 1912, and their surveyors and geologists had a busy time, and by the end of the period more than 11,000 zaiavkas had been selected.

Other companies subsequently acquiring territory within the area of the original concession were the Emba, Messrs. Nobels, the Emba-Caspian, the Kolchida of Baku, and others.

Up till now Dos-Sor has been the main centre of development. It was brought into prominence by well No. 3, of the Ural Caspian Co., which on May 13th, 1911, from a depth of 732 ft., spouted with great violence; after one and-a-half days it caught fire and

destroyed the derrick, but was finally arrested. It began to flow again in February, 1912, was closed down, and reopened in October, 1912, when in the first 24 hours it gave 120,000 poods (1,944 tons), and then settled down to 50,000 poods. Oil from it was received into an ambar, earth reservoir, but this broke down, through flooding after heavy rain, and about 300,000 poods were lost. The well was then shut down till proper storage was built. This famous gusher is estimated to have produced in the early part of its history from 1½ to 2 million poods. It has since produced nearly 7 million poods. Last July it was stopped for cleaning, and re-drilling.

Since the Ural-Caspian No. 3 came in several other fountains have been struck at Dos-Sor by the same company, also by the Emba Nobel, and more recently by the Emba-Caspian Co., and the production from this centre has steadily increased. It is still the only field from which oil has actually been exported. There are now some 59 wells yielding oil, Ural-Caspian Company 32, Emba-Nobel 21, Emba-Caspian 6.

During 1912, Dos-Sor was connected by telegraph with Guriev. At the end of that year it was still a very small place, but a big building programme was then commencing. Pipe-lines were being laid both by the Ural-Caspian Co. and by Messrs. Nobels to the fishing village at Rakusha, at which point the oil is shipped, and where refineries have been constructed.

Owing to the activities of the various Companies mentioned above, the difference in Dos-Sor as seen late in 1912, and again in 1914 is startling, and it is now quite an important settlement with a population of over 2,000. The accommodation for the staffs and workmen is good, and up to date, as are also the schools, religious establishments, sanatoria, and provisions for recreation. The chief difficulty, as the place grows, is to obtain a sufficient supply of good water. The administration of the different companies has been gradually moving from Guriev to Dos-Sor.

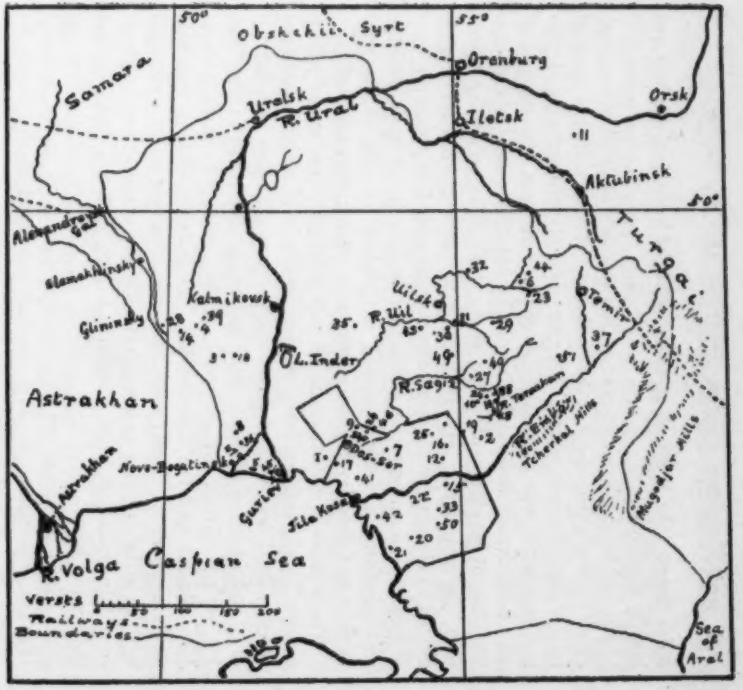
At Makat and Iskene a little drilling has been done since the Concession was taken over in 1910, but without any important results. However it was announced, early this year that the Emba Nobel Co. had a fountain at Makat. Preliminary work or trial drilling has been carried out also at Bli-ule, Bek-Beké, Iman Kara, Satep Aldi, and at other spots.

Drilling by the Canadian-Galician system was employed in the first place by the Ural Caspian Co., but gradual modifications have been introduced by their engineers to suit the special requirements of the district. The Russian percussion system is also used by

List of Localities indicated by numbers on the map.

INDICATIONS OF OIL.

1 Abjel.
2 Alasha Kazgan.
3 Aldi Bergen.
4 Aukatai Tchagil.
5 Baian Bet.
6 Babili Kumdi.
7 Bek-Beke.
8 Bertaga.
9 Bliule.
10 Djaman Kablandy.
11 Djusa.
12 Djushali Sai.
13 Donguliuk Kul.
14 Erke Tchagil.
15 Esek Djal.
16 Iman Kara.
17 Iskene.
18 Kagaz Tchagil.
19 Kara Murat.
20 Karatchungul.
21 Karaton.
22 Kaskir Bulak.
23 Kinjaldi.
24 Kizil-Djar.
25 Koi-Kara.
26 Kok-Tiube.
27 Kora.
28 Kukurti.
29 Kumchukat.
30 Kurdakti.
31 Mai Kuduk.
32 Maili Sai.
33 Mainili.
34 Makat.
35 Maten Hoja.
36 Mursala.
37 Murtuk (or Mortuk).
38 Murzanyn Adir.
39 Nasbek Sor.
40 Nugaiti.
41 Satep Aldi.
42 Sor-Tiube.
43 Tamdi Kul.
44 Tchegarli Kumdi.
45 Tchernaia Rietchka.
46 Tchingildi.
47 Tegen.
48 Tersakan.
49 Tobekuduk.
50 Ushkan.
51 Yakti Sai.



other firms. On account of the scarcity of water, oil-engines are largely employed.

The sudden outbreak of war in the summer of 1914 put a great check on the development of the Uralsk and of other oilfields. Capital immediately became scarce. A great deal of prospecting and preliminary work was necessarily stopped, and even the companies who were already well established had great difficulties to overcome. The loss of employés of every grade, difficulties regarding transport, the requisition of automobiles for Government service, all tended to disorganise their industry. All available resources were devoted to continuing the production from existing wells, drilling was confined to wells expected to produce shortly, while trial borings and new developments were to a great extent arrested.

The centres of development already referred to are in the "Concession" area, and are being worked by the companies established there. Trial drilling and other exploratory work has been carried out, and in some cases is still proceeding, in spite of the war, by various firms, at different places, some of them remote from Guriev and the Caspian Sea. It is impossible to get particulars of all of these; the operations are generally conducted with as little publicity as possible, and at the present time it is hard to get information from Russia. A few of them, however, are referred to here.

At Novo-Bogatinsk on the Cossack lands, 88 miles west of Guriev, exploration by deep drilling has been started lately by Messrs. Nobels, and by the West Ural Company.

The former firm put down a well in 1912, finding some oil and a great deal of gas, this was followed by other trial wells with some success, but the exact results obtained were not made public.

In 1914 the West Ural Co. drilled two deep wells by the rotary system. Finally, in August 6th of this year Messrs. Nobels struck a gusher, stated to have given an estimated yield of 300,000 poods in 24 hours. This is of considerable interest and importance, as the Cossack lands, west of Guriev, present somewhat of a geological puzzle, and differ a good deal from the Dos-Sor district. It is stated also that a Moscow firm, which has more recently started work in this district, has struck a small gusher.

At Tchernaia Rietchka, near Guriev, where surface indications of petroleum gas were observed some years ago, a little oil was found in some shallow boreholes near the tomb Kara-Kis in 1913, and in 1914 Messrs. Nobels were drilling a trial well a little farther west.

At Maten Hoja (or Kuza) some 80 versts east of Kalmikovsk, Messrs. Nobels drilled a 300-ft. hole near a strong seepage of oil and

gas in 1913, but got no result. In 1914 another well beginning with 16 inches diameter was started. A report referring to the striking of oil recently would appear to refer to this spot, or at least to this district, judging from the position described, although the name Maten Hoja is not used (this tomb, it may be remarked, is about 3 miles from the boring site selected last year, which might account for the name not being employed).

In the Novo-Kazanka district, Glininsky, the same firm are stated to have found good oil at small depths in several shallow borings.

At Djusa, just outside the Uralsk province, in Turgai, a good oil of light sp. gr. is said to have been obtained during 1914 at small depth.

At Murtuk by the Temir river, oil is reported to have been struck.

Drilling was stated to be proceeding in the Karagandy gorge, by Messrs. Nobels, and at Kara Dzhidele by the South Eastern Petroleum Co. These spots are both in the Temir district.

Attention has also been turned of late, east of the Uralsk province, to that of Turgai.

Pipe-lines and Storage.—There are two 6 in. pipe-lines taking oil from Dos-Sor via Iskene, a distance of 45 miles, to Rakusha, the shipping port, where the refineries are situated. On account of the shallowness of the water, pipe-lines are laid on the sea bed, and terminate at platforms 6 miles out, where the barges can moor. Of the two lines from Dos-Sor, one belongs to the Ural Caspian Co., and is underground and embedded in cement, the other belongs to Messrs. Nobels, and is exposed. The first-mentioned line was at first provided with one pump, and could only handle 30,000 poods per diem. The addition of a second pump increased its capacity to 52,000 poods.

At Rakusha the Ural Caspian Co. have tank storage for 7 million poods, besides considerable tankage at Dos-Sor.

There is a trifling difference in the price of oil at Rakusha and that at Baku on account of the greater difficulty of shipping at the former place.

Refineries.—At Rakusha refineries have been erected by the Ural Caspian Oil Co. and the Emba Co. The refining of oil in the district was undertaken in the first place with a view to getting the rebate of 50 % of the excise duty on refined products, granted as one of the privileges of the concession.

When this condition ceases, the question of refining oil at Rakusha will have to be considered entirely on its merits, and may possibly be discontinued.

As to the results obtained by refining, we may quote from a report of the Ural Caspian Co. that in April-October 1914, when the first trial distillations were made, a quantity of 6,798,122 poods gave—

	Poods.		%
Gasoline	24,830	.....	·36
Kerosene	1,607,366	.....	23·66
Residues	5,094,009	.....	74·92
Loss	71,917	.....	1·06

The oil from the first gusher, No. 3 Ural Caspian Co., was described as of sp. gr. 0·861, greenish, and of good quality. The oil from another well, No. 10 of the same company, and coming from the same horizon as No. 3, was lighter, sp. gr. 0·85, and, it is stated, could be used very well in lamps. From Karatchungul, oil in specific gravity, 0·828, 0·858, and 0·853, and from Karaton of 0·867, have been obtained.

Seven samples of oil from the Guriev district are stated in Redwood and Eastlake's pocket-book to have specific gravities of 0·839, 0·869, 0·876, 0·880, 0·903, 0·904, and 0·908.

An examination of oil from the Dos-Sor well No. 3 (the spouter), by Prof. Herr, gave—

Specific gravity 0·8614. Viscosity at 50° C = 1 (Engler).

0—100° C	1·1 %	100—125° C	1·9 %
125—275° C	28·0 %	Residuum	68·0 %
Paraffin content	0·02 %		

The flash-point of the sample was stated to be low, but that of the residuum (68 %) was 122° C, and its viscosity at 50° C = 2·4 (Eng). It is described as giving a good lubricating oil.

Production. As already stated, up to the present time petroleum has been obtained in commercial quantities at Dos-Sor only.

During 1912 the production, only just beginning, is stated to have amounted to 1,017,000 poods. In 1913 the quantity was about 7,182,000 poods, and by the close of navigation in 1914 (statistics down to October 1914) another 12,923,000 poods had been produced, making the total amount, from the beginning in 1912 to the close of shipping in 1914, some 21,122,000 poods, or 340,487 tons, of which it was estimated that the different companies produced in the following proportions:

Ural Caspian Oil Corporation...	60·8 %
Emba (Nobel)	38·0 %
Emba Caspian	1·2 %

The above figures do not, of course, take into account the oil lost from the great gusher, estimated at 1½ to 2 million poods.

Comparison with other areas is somewhat premature, as the Uralsk-Emba fields are still in the infancy of their development, but according to an estimate of the first nine months' production of the current year (1915) Dos-Sor produced some 18 million poods, which is just equal to the production for the same period in 1914 (first nine months) of Holy Island, Maikop, Tcheleken and Fergana combined (the joint production of these four oilfields was somewhat greater for 1915, 16 million poods, largely due to the Maikop gusher).

The production for the same period, Jan.-Sept. 1915, of Russia was 426 million poods, of which 331 million came from Baku and the Apsheron peninsula. These figures are only approximate.

The rapid increase in production may be seen from the official figures of one company (the Ural Caspian Oil Corporation). Beginning with the small production of 1912, there was—

In hand in April 1913	1,128,000 poods.
April 1913–April 1914 (12 months)	5,658,430 „
April 1914–November 1914 (7 months) ...	6,056,868 „

while for the last 12 months (November 1914–November 1915), the production of this company was 10½ million poods, while their shipments in 1915 were about—

Kerosene	1,390,000 poods
Crude	1,780,000 „
Residuals.....	7,441,000 „

It is estimated by the Ural Caspian Oil Co. that their 32 producing wells, if allowed to yield without restriction (i.e. if questions of transport, storage, labour, etc., did not impose any limits), are capable of producing from 350,000 to 400,000 poods weekly.

Geology and Occurrence of Petroleum.

The great plain which occupies all the central and western portions of this country, is very barren of geological indications of any kind, the whole surface having been levelled and overlaid by the recent sediments of the Caspian Sea, a few isolated outcrops, and the data obtained from pits and boreholes, being the only evidences of structure available.

In the east and north-east of the area, exposures are more frequent in hills, and in the ravines cut by rivers through the plateau lands.

On the flanks of the Mugodjar hills are developed Devonian rocks, followed by Carboniferous, but these do not appear within the limits of the area we are considering.

The great Permian platform of Russia, which stretches from the Arctic sea to the Caspian, extends, to the north of this area, between Uralsk and Orenburg, and includes the important salt deposits of Iletzk. It underlies the whole of the petroliferous territory, but is only occasionally exposed as isolated inliers.

Unconformably upon the Permian lie Jurassic followed by Cretaceous rocks. In the western part of the area these have been subjected to considerable disturbance and denudation, and have subsequently been covered by the recent deposits which vary in thickness from point to point, with the irregular surface of the Secondary rocks.

Eastward the Cretaceous projects through the Recent cover as small hills, and again farther east is exposed continuously, covered in most places by Tertiary or Recent outliers, in the upper part of the basins of the rivers Emba, Sagiz and Uil, and in the basin of the Temir.

The Chalk is represented by marls followed by marls and clays with *Belemnitella lanceolata*. These are classed as upper Senonian. They pass into lower Senonian clays, at the base of which occurs a phosphorite breccia, with sponge remains. The Senonian has a sandy facies in the upper part of the Temir river.

Below the breccia follows a series of sands and clays. In the basins of the Uil, Asche Uil, Sagiz and Tersakan, Cenomanian fossils are found in this series. A lower portion of it is exposed in the rivers Emba and Kainar, and in the hills Koi-Kara and Iman-Kara. At Koi-Kara this series is underlaid conformably by Upper Jurassic clay.

Although the whole region was submerged in Tertiary times, rocks which may with certainty be assigned to this period do not play any important part in the structure. In the east and south-east occur sands and clays assigned to the Miocene, and also beds of Oligocene and of Eocene age. In the west to the north of Lake Inder, and at other places, are some deposits classed as belonging to the Aktchagil (Miocene) series.

While some remains of undoubted Tertiaries are encountered in the west, other deposits classed by certain investigators as late Tertiary, are just as likely to be Recent (Caspian), the only evidence advanced being ill-defined fossils, belonging to genera common to the Tertiary and the Recent periods. All this is of little importance, but the fact that beds generally accepted as Permian have by some authorities been assigned to the Tertiary, and even to the Recent epochs, is referred to later as being a question which has an important bearing on the search for oil in certain parts of the country.

Although the Ural range with its N.N.W. trend was already in existence before the deposition of the Permian, the forces which produced it appear to have continued to act for a long time subsequently.

Later movements of E.S.E. trend upheaved the Caucasus, and the parallel Mangischlak peninsula, affecting beds of late Miocene age.

The complicated system of flexures occurring in the region north of the Caspian Sea appears to be due to the conflict of these two forces.

The Mugodjar hills suggest that the southern extremity of the Ural range has been slightly curved to the westward. A N.N.E. strike is observed in flexures of the gypsum west of Guriev, and near Lake Inder.

The undulations of the Cretaceous and Tertiary are not sufficiently pronounced to warrant the formulation of any general trend.

In the low-lying plain which occupies the southern and western parts of the petroliferous area, seepages occur at many points, the oil escaping from the reservoir beds, and finding its way up through the Caspian sediments, spreading as it does so, often in the neighbourhood of the "sors," or lakes, which abound in the plain.

In some places "gas-holes," around which there is often a deposit of sulphur, are met with. Although not necessarily indications of petroleum, they appear generally to be associated with it in this region. Some of these spots are venerated by the Kirghis, and are surrounded with little sticks with small pieces of cloth, etc., tied to them, the votive offerings of the pious.

The indications which first drew attention to the Dos-Sor-Iskene-Makat area, were seepages of liquid oil rising through the sands. At Makat the reservoir beds are brought near the surface, and in shallow pits under a few feet of recent deposits, beds with Lower Cretaceous fossils are exposed.

It is, however, in the higher lands to the east that the evidence as to the age of the oil-bearing beds is to be found. In some places they crop out on the sides, or at the feet of hills, as at Iman-Kara, Kara-Murat, Alasha-Kazgan. In other places the exposure of the petroliferous strata is due to erosion by rivers.

The beds from which the oil issues, or which have deposits of "Kir" (asphalt) at their outcrops, belong to the series of sands and clays, already referred to, as underlying the chalk. The most valuable data, gained through prolonged study of the district and of the well-records by their resident geologists, are of course the private property of the companies operating in the oilfields,

and are not available. We may, however, safely conclude that the reservoir rocks in which the oil is stored, under the Caspian sediments, belong to the lower part of the Cretaceous (possibly also, in part, to the Jurassic). This, however, does not settle the question of the origin of the oil, the reservoir not being necessarily the bed in which the oil was formed.

The Permian is known to be petroliferous in Kazan, Samara, Simbirsk, Ufa and Orenburg, and may be the source of some if not of all the oil in the Ural-Emba district.

It has already been stated that some rocks generally considered as Permian, have also been assigned to Tertiary and Post-Tertiary times. The gypsum of Karatchungul and that west of Guriev have both been the subject of some controversy, and will be briefly discussed here. At Lake Karatchungul, through the sands of the surrounding plain rises an island of gypsum, in which a hollow has been formed by solution of the rock. Under the Caspian sediments Cretaceous rocks are found, and the presumably Permian gypsum appears to rise through a cover of Cretaceous.

The view however has been advanced that the gypsum is recent, a deposit of the Caspian Sea, and that the Cretaceous has been brought near the surface in places by folding, the hollows in the Cretaceous being filled by gypsum. This idea appears to have been suggested by the finding of some recent shells in a deep borehole in the gypsum. Such evidence however is not convincing. Shells from the overlying sediments may easily fall into a borehole, or again, there may have been deep hollows in the gypsum formed by solution before the Caspian Sea covered the area. There exists such a hole to the west of Guriev, described by the inhabitants as a bottomless pit. In any case it is difficult to conceive of beds of gypsum nearly 1,000 feet thick being deposited by the Caspian Sea in recent times.

At Inder, near the east bank of the Ural river, and about 150 versts north of Guriev, is a salt lake, with gypsum cliffs on its northern shore. A broken chain of hills some 200 feet high, 40 versts long, and 7–10 versts wide, with a general N.W.–S.E. trend lies to the north of the lake. The north-western extremity of this range reaches the Ural river.

To the north of the lake the gypsum, with a conformably overlying sandstone, strikes N.E., and dips steeply to S.E., being, in places, turned over. Anticlinal structure is clearly observed in the gypsum.

On the west flank of the anticline a series of Jurassic beds lie unconformably, identified by fossils as Callovian and Portlandian.

Following these, to the west are calcareous clays, and finally the white chalk. These beds, unlike the gypsum, have a north-westerly strike, and a south-westerly dip. At the west of the range, at a place called Biele Rostosch, the white chalk is overlaid by beds assigned to the Aktchagil (Tertiary) series. The position of the gypsum here, relatively to the other beds, sufficiently indicates its pre-Jurassic age.

The same general strike of the gypsum is also observed to the east of Lake Inder to be N.N.E., with an easterly dip about 25°.

To the west of Guriev, between that town and the Tchernaia Rietchka, or Black River, several low anticlinal ridges of gypsum, yellow sandstone, and mudstone project through the Caspian deposits, striking N.N.E. A small island (Kameni Ostrov, or Stone Island) about 4 versts out in the Caspian Sea, showing the same material and strike, is a prolongation of these folds.

Going towards the tomb Kara Kis, which is on the Black River, 5½ miles west of Guriev, the gypsum is found in boreholes at successively lower levels, and at Kara Kis, where evidences of gas had been previously observed, small quantities of oil were found in 1913 in shallow boreholes, above the gypsum. Further west the gypsum is lost sight of, but is found again by drilling at Novo-Bogatinsk, together with great thicknesses of salt.

The view has been advanced that, to the west of Guriev the Caspian deposits are underlaid by a considerable thickness of Tertiary beds, and that the gypsum and salt beds here are much younger than those reached by drilling on the oilfields to the east (in the "concession" area). The similarity between the conditions of the gypsum west of Guriev and at Inder, are, however, sufficiently striking, and in the absence of further evidence it seems most reasonable to ascribe the gypsum of Tchernaia Rietchka, and of Karatchungul, like that of Inder, to the Permian.

Transport.

All goods for Guriev, and for the oilfields, are landed at the Preestan or port, 8 miles from Guriev. As already stated, the steamers cannot come to the shore, and the goods are either carted in from the tugs, or when the water is high enough (when the wind is not blowing off the shore) barges of light draught can be brought alongside the piers, to discharge, and in this way heavy machinery can be got ashore.

Further transport is effected in carts, drawn by horses or camels to Guriev, and then across the Ural river to the oilfields. This cartage of machinery, casing, provisions, etc., to the different

centres has been a valuable source of employment for both Cossacks and Kirghiz. A number of automobiles are in use in this country now, but the older method of traction, though somewhat slow, is still the most reliable and economical for heavy goods.

Water Supply.

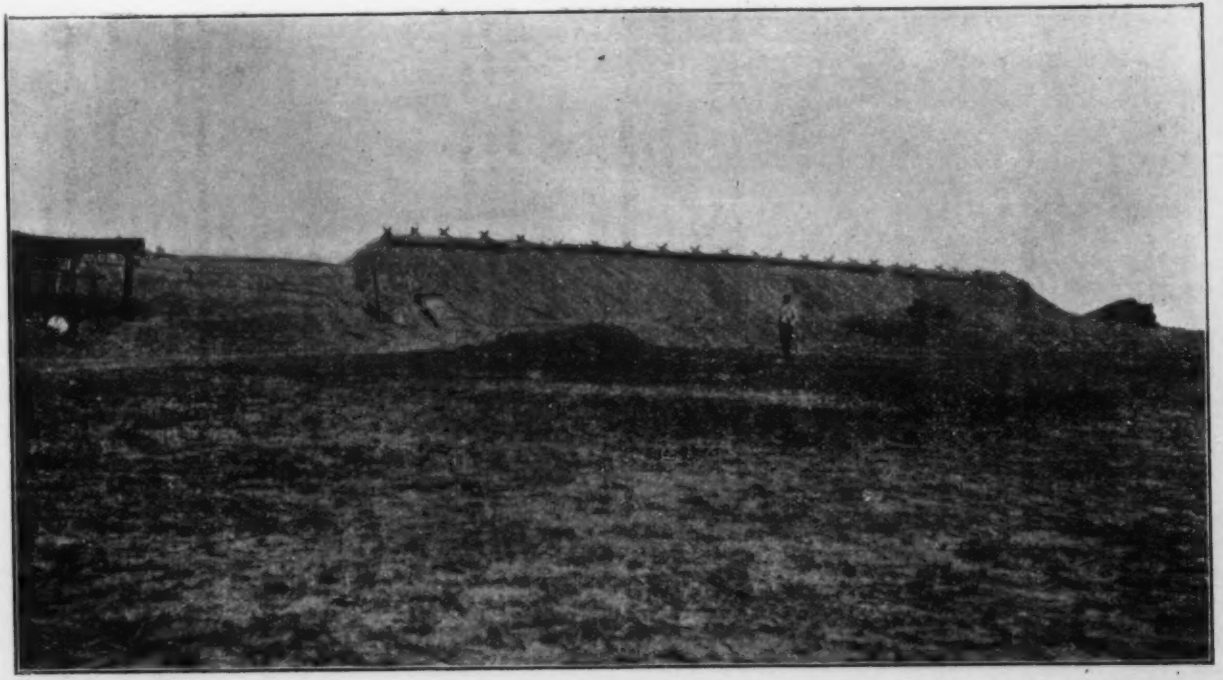
In Guriev each house has in its yard, or outbuildings, one or more large barrels or tanks for water storage. The water is brought to them by men who make a business of fetching it from the Ural river, into which they drive their water carts, which consists of a large, long barrel laid on its side with a square hole on the top (really on the upper "side") mounted on a low cart. The scarcity of water in some parts of the steppe, already referred to, has caused much inconvenience at some of the centres of development, Dos-Sor, Iskene, Makat, etc. Water had to be carted from distant wells to these places, an expensive and inadequate method. The difficulty was to a certain extent overcome by the device of storing snow, during the winter, in long deep trenches, roofed over with non-conducting materials. Water is drawn from a sump, at the end of the trench, and keeps quite cold, even during the hottest summer. Fig. 19 (opposite) shows the snow store at Iskene.

The road from Guriev to Iskene, Dos-Sor and Makat, is on a very dry part of the steppe, and several small stations have been erected, where water is stored, for the use of the companies' employés, horses and camels, on the road. The water has of course to be carted to these stations. There has been talk, for some time, of bringing water by pipes from the rivers to the oilfields, and there is no doubt that sooner or later, something of the kind will have to be done. At present some automobiles are being used to bring water from the river Sagiz, and other sources.

List of Places at which indications of Oil are found, with notes.

It must be pointed out that by this time drilling may have been begun at others of these places, and further information have been obtained than is given in this list. To facilitate finding the places on the map, without fully describing the position of each, they are classified in five areas, the number of its area being stated after the name of each place:

(1) Cossack lands. West of Ural river.
(2) South-west area, east of Ural river, and west of long. 54°.
(3) South-east of Emba river.
(4) Between the rivers Emba and Sagiz, east of long. 54°.
(5) North of the river Sagiz, and in the basin of the river Uil.



Abjel (2). Seepages.
Alasha Kazgan (4). Asphalt on a hill, and also in the valley.
Aldi Bergen (1). Seepages of oil and gas.
Aral-Bey. See Slamahinsky.
Aukatai Tchagil (1). See Glininsky.
Baian Bet (1). Indications of oil and gas.
Babili-Kumdi (5). Seepage.
Balam Tchali = Babili Kumdi.
Bek-Beke (2).
Bertaga (1). Indications of oil and gas.
Bliuli (2). Seepages, deep trial drilling.
Djaman Kablandy (4).—Oil, bitumen.
Djusa. In Turgai, oil found, trial drilling.
Djushali Sai (4). Seepages.
Donguliuk Kul (4). Asphaltic sandstone.
Dos-Sor (2). Important centre of production, gushers, flowing wells.
Erke Tchagil (1). See Glininsky.
Esek-Djal (3). Seepage.
Glininsky (1). Indications of oil, gas, sulphur, reported from four localities near Glininsky, Erke Tchagil, Aukatai Tchagil, Kukurti and Nasbek Sor. Trial drilling is said to have found oil sands at moderate depths.
Iman-Kara (4). Oil and asphalt in Cretaceous rocks, outcropping in valley, trial drilling.
Iskene (2). Big seepages in salt lake. Oil found in several wells.
Kagaz Tchagil (1).
Kara Djidele. In Temir district, trial drilling.
Karagandy. In Temir district, trial drilling.
Kara Murat (4). Seepages on top and east side of hill.
Karatchungul (3). Seepages and wells with oil near salt lake in gypsum. Gusher at 142 feet in gypsum. Indications of oil at 1,000 feet in gypsum.
Karaton (3). Seepages, oil in several shallow wells, a little oil baled here lately.
Kaskir Bulak (3). Seepages.
Kinjaldi (5). Seepages.
Kizil-Djar (4). Heavy oil, pitch.
Koi-Kara (4).
Kok-Tiube (2). Seepages.
Kora (5). Asphaltic sandstones, Cretaceous.
Kukurti (1). See Glininsky.
Kumchukat (5). Seepages.
Kurdakti (5). Seepages.
Mai Kuduk (5). Seepages. (Also shown as Maili Sai.)
Maili Sai (5). Seepage? information doubtful, this name appears twice on some map, as Maili Sai north of the Uil river, and also at Mai-Kuduk on the Asche-Uil river.
Mainili (Munaili) (3). Seepages thick oil, and bitumen.
Makat (2). Several wells drilled, oil beds come very near surface, gusher reported lately.
Maten Hoja } (5). Extreme west of group 5, near Kalimkovsk, oil seepages.
Maten Kuza } Trial drillings (oil struck lately in well?)
Munaili (3). See Mainili.

FIG. 20. Water Carts, Dos-Sor.

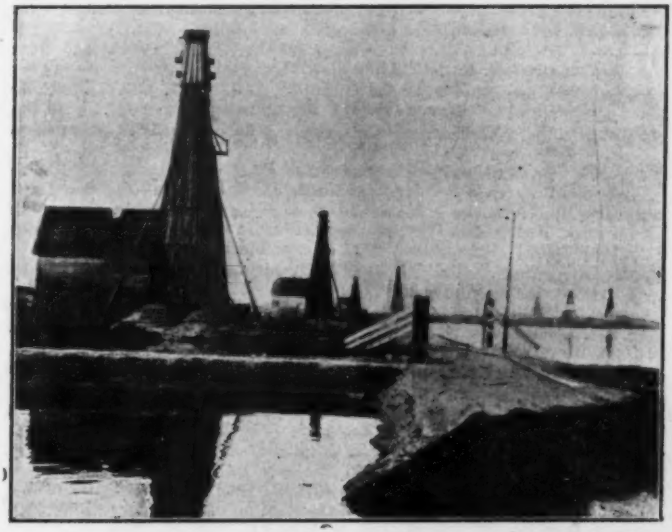


FIG. 21. Derricks and Ambars, Dos-Sor.

Mursala (1). Seepages.
Murtuk (4). East of Temir river, seepages, trial drilling.
Murzanyn Adir (4). Asphaltic sandstone.
Nazbek Sor (1). See Glininsky.
Novo-Bogatinsk 1. Seepages on a N.E.-S.W. line, wells with oil and gas, gusher struck lately.
Novo Kazanka (1). Same as Glininsky.
Nugaiti (5). Seepage.
Satep Aldi (2). Seepages.
Slamakhinsky (1). Aral-Bey, indications of oil and gas.
Sor-Tiube (3). Seepages.
Tamdi-Kul (5). Seepages.
Tchegarli Kumdi (5). Seepages.
Tchernaia Rietchka (1). Also called Kara Kis, as near the tomb Kara Kis on the "black river" are gas holes, oil at shallow depths, gypsum crops out to the east, with anticlinal structure, strike N.E.
Tchingildi (2). Seepages, trial drilling.
Tegen (1). Indications of oil and gas, near Novo-Bogatinsk.
Tereskan or Terskan (4). Seepages.
Tobekuduk (5). Seepages?
Ushkan (3). Seepages.
Yakti Sai (4). Seepages.

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DISCUSSION.

The President said he was sure the Members would agree that the author had presented a remarkably comprehensive account, of high instructional value, of a region which was destined to become of great commercial importance in respect to the supply of petroleum. Incidentally he desired to add—and he was sure the Members would endorse the addition—that the author had shown himself also to be an able and entertaining lecturer.

Having regard to the great difficulties attending the work of development in the region which the author had eloquently referred to, it was really remarkable that so much should have been accomplished in so short a time. He felt considerable personal interest in the region described, because he thought he was right in stating that his colleague, Mr. Arthur Eastlake, the Honorary Secretary of the Institution, was the first British petroleum technologist to make a visit of inspection there; and he believed he was also right in stating that it was very largely the favourable deductions he (Mr. Eastlake) drew from the comparatively little that could then be seen which gave an impetus to the development of certain portions of that vast petroliferous region. Undoubtedly those conclusions had been most amply justified by the results which had been obtained.

The information which the author had given was much needed, and there was no one better qualified to undertake the task of furnishing it. Mr. Holiday had spent many months in the region, and therefore what he said was the outcome of first-hand knowledge. He had paid in all three visits to the territory, two in 1912, and then, after carrying out certain work in other parts of Asiatic Russia, he returned to the region which he had described in the paper in 1914.

But neither when he returned, nor previously, was he well treated by Nature. In the first place, the expedition which he undertook in 1912, an expedition of an adventurous character, very nearly came to an untimely end, and the whole of the members of the party narrowly escaped with their lives in consequence of lack of water. It almost seemed as if, when he returned in 1914, Providence had decided to run no risks in that direction, for in the latter year there were continuous rains and unprecedented floods. The author then found that an excess of water was almost as bad as a scarcity. However, he was a man of indomitable courage and immense perseverance, and on each of the occasions he added to his store of knowledge; and, although he had conducted the work under con-

ditions of exceptional difficulty, he had acquired, as the members would have gathered from the paper, an immense store of extremely valuable information.

There were several present at the meeting who were able and might be willing to further enlighten them on the subject, and he would call upon Mr. Hume to open the discussion.

Mr. E. Hume said the members would probably think it rather presumptuous on his part to address them after they had listened to the author's well-prepared paper, which was so full of technical and geological knowledge. Personally, he had no such scientific knowledge, his abilities being merely financial. On the other hand, it might perhaps be considered less presumptuous on his part if he stated that he was the father and the mother of the Ural-Caspian Oil Corporation.

To make the story a short one, he obtained an option on the concession in 1909, and in the early months of 1910 Mr. Arthur Eastlake visited the country, and reported to Sir Boverton Redwood, amongst other conclusions, that Dos-Sor was the best field that he had seen in his short visit, recommending immediate drilling there. He had made a map as the result of his geological researches, and pointing to Dos-Sor, said, "Here is where we ought to sink a well." That map was sent out to the engineers on the ground, and as a result the biggest oil-well that had ever been found in the country was discovered. The author had described practically all the peculiarities of the country. The speaker had gone there in the autumn of 1910, and the steppe was civilised now, compared with what it was then. The Kirghiz only visited that part of the steppes in the summer with their flocks, and returned to warmer climates in the winter, only the tombs of their dead remaining.

The author had described Guriev as the biggest town in the district: in 1910, the only map of Europe to be seen there, was one of 1812, and the owner, the Tartar Kirghiz schoolmaster, could not part with it on any account. When oil-field work started, all the necessities of life had to be transported; houses had to be built and water and provisions had to be provided: Dos-Sor now has a population of 3,000 inhabitants.

Two oil-bearing strata had so far been discovered at depths of, roughly, from 400 ft. to 450 ft., and 700 ft. to 750 ft., and the yield made it unnecessary to seek for deeper-seated horizons. The drilling presented no difficulties whatsoever, and the shallowness of the wells made the cost very moderate.

One of the great difficulties connected with transport was the shallowness of the Caspian Sea at this northern margin. At Baku

deep water was available, oil being there put into big steamers which had a draught of 12 ft., and off Astrakhan these had to discharge into barges for conveyance up the Volga. The sea on this north and northeast coast generally, was so shallow that the pipe-line through which the oil was pumped into the barges at Rakusha was, he believed, something like six or seven miles long out to sea, because the barges could not come in any nearer. So far as the future of the field was concerned, Baku was far better situated for the export of oil to Europe, whilst the Uralsk field had greatly the advantage for the Russian home trade. He believed the future development of the field lay in the construction of a pipe-line from Dos-Sor and the other producing fields of the region right up the Volga to Saratov or Samara. If the oil was pumped up that way, the natural disadvantages of the flat seaboard on the Caspian Sea would be entirely overcome, and the trade for Russian consumption could be more economically conducted than at Baku.

The Ural-Caspian Corporation had now entirely done away with all ambars. The Russian Government now only allowed the pumping of oil into ambars in case of necessity, such as an unforeseen fountain when the oil could not be transferred at once to the ordinary steel tankage. The Ural-Caspian Oil Corporation had at present tanks of ten million pud aggregate capacity.

Mr. E. S. Ward said he had been favoured with an opportunity of studying the Permian of Samara Province, where this formation is well exposed over a large area. The characteristics that impressed him most were the general friability and porosity of the series, and the consequent rapidity of erosion and denudation, also the occurrence of gypsum throughout the series in beds of increasing thickness downwards. In the Upper or Tatarian division of the Permian he found gypsum in a concretionary form, but lower down, in the Zechstein, it was in thick, regular beds. The petroliferous nature of the Zechstein division of the Permian in that region was undoubted. The almost entire absence of clays to form an impervious cover to the oil-bearing beds was a conspicuous feature.

It would be very interesting to know how far pre-Jurassic denudation had been carried in the Permian of the Uralsk region. It would seem as if it could not have been carried very deep, as in that case all the oil would have been lost before the deposition of the Mesozoic rocks.

Mr. P. C. A. Stewart enquired whether the whole 45 miles of the pipe-line to which the author had referred was buried in cement, or the land portion only.

Mr. D. A. Sutherland thought it would be of great interest if the author could give the logs of any of the wells.

Mr. H. May enquired whether any difficulty was experienced, in view of the extreme cold, in pumping the oil through the pipe-line, and, if so, whether any special means were adopted for overcoming it.

Mr. F. A. Holiday, in reply, said that Mr. Hume's remarks were of particular interest, because that gentleman had seen the region described in the paper in its primitive state.

A question had been asked as to whether the whole of the pipe-line was buried in cement? He had never been to Rakusha, so that he had not seen the sea end of the pipe-line, but he believed only the part of the line that was on land was laid in cement. He was, however, not quite sure on the point.

With regard to the particulars of the wells, he wished he had logs of them, but the details were not published, and were kept very quiet. He knew a lot of engineers working for the company, but they would not give any information. A few logs appeared in a report a long time ago in reference to some shallow drilling which was undertaken by the first explorers. Most of those wells were too shallow to be of any real interest, and they did not throw any particular light on the source of the oil. That was why the information obtained in the eastern part of the district, where rocks were exposed, was of great interest. A great deal of information had been obtained from logs, and many geological maps had been made from them, but the outside public was not allowed to see them.

A question had been asked as to whether any difficulty had been experienced in pumping the oil through the pipes owing to the effect of cold on the oil. He was not aware of any such difficulty, and he was not acquainted with any artificial means that had been used to make the oil less viscous for pumping purposes.

In conclusion, he desired to thank Mr. William Sutton, Member of the Institution, Mr. Hume, a Director, and Mr. Turner, the Secretary of the Ural-Caspian Oil Corporation, for photographs from which the slides had been made, and also the Honorary Secretary and the Honorary Librarian of the Institution, who had very kindly helped him at various stages during the preparation of the paper.

On the motion of the President, a very hearty vote of thanks was accorded to Mr. Holiday for his most interesting paper, and the meeting terminated.

Subsequently Mr. STEWART sent in the following further queries:

Was the pipe-line buried in order to prevent its being molested, or to prevent action of alkaline desert salts?

What was the thickness and composition of the concrete setting?

On these points Mr. HOLIDAY replied as follows:

The pipe is underground, and I have not seen it. I was informed that it was protected by an asphaltic cement, and part of it with the addition of jute. This might afford protection in several ways. The elastic covering would prevent fracture by blows, accidental or malicious. The impermeability would prevent oxidation by the saline moisture, and the non-conducting cover would repel the heat of the sun. I do not know what protection, if any, is afforded to the portion of the pipe lying in the sea.

Eleventh General Meeting.

The Eleventh General Meeting was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C., on Tuesday evening, 18th January, 1916, Sir Boverton Redwood, Bart., D.Sc., F.R.S.E., President, occupying the Chair.

The Members of Council present were: Prof. John Cadman, Messrs. E. H. Cunningham Craig, Arthur W. Eastlake and Robert Redwood. A message of regret for unavoidable absence was received from Dr. F. Mollwo Perkin.

The following paper was read, illustrated by many lantern slides.

Oil Storage.

By HERBERT BARRINGER, M.Inst.C.E., M.I.Mech.E., M.I.N.A.,
Member.

FROM the earliest times, the finding of oil necessitated some form of storage in close proximity to the source of supply, in which it could be accommodated until arrangements for its distribution were completed. This generally consisted of a rough hole dug in the ground and lined with clay, or else of comparatively small vessels of wood or earthenware.

As the industry developed, and larger quantities of oil had to be dealt with, the primitive hole or pond developed into the large pit or sunken reservoir still used on the American Continent, Russia and other countries. The simpler form consisted of a circular excavation, the bottom being of smaller diameter than the top, the sides and bottom lined with clay to render them oil-tight, and the top open, although sometimes a light roof was formed of thin iron plates supported on wooden rafters. Another form of this type of

storage consists of a rectangular excavation some 112 feet in length and 70 feet in width by about 26 feet in depth, the upper portions of the sides and ends being vertical, and the lower corners shaped off to a narrow bottom: the sides and ends are generally lined with wood puddled at the back with clay, and sometimes the bottoms also. In the case of deep cylindrical reservoirs excavated in the earth it is necessary to line the sides with timber to retain the walls.

In Galicia underground reservoirs are extensively used; in most cases the roofing is of wood covered with felt and asphalted.

Wooden cylindrical tanks placed above ground, although not of large capacity, are used to a considerable extent in America. They are formed of staves secured by steel hoops.

The use of iron for tanks naturally followed, and later on steel displaced the iron, and is now generally the material employed, especially in storages removed from the immediate vicinity of the wells.

The first introduction of storage of petroleum in bulk in this country was in connection with the importation of oil in barrels, and was adopted in order to reduce the amount of oil lost by storage in these vessels. If oil had to be stored for some time, the barrels were emptied into tanks, generally of a rectangular form, and often sunk in the ground, and from these tanks oil was drawn off into barrels as required for delivery. Mellish's and Palmer's wharves were probably the first storages of this class, and were so adapted in 1868 or 1869.

The advent of the steamship bulk-oil carrier at once necessitated the provision of storage installations all over the world for the reception and storage of cargoes, with arrangements for distribution as required. It is proposed in this paper to deal with the question of oil storage under the following headings:

1. General principles of installation.
2. Foundations and construction of storage-tanks.
3. Details of machinery necessary to deal with the reception and delivery of oil cargoes.
4. General features of existing installations.

I.—General Principles of Installation.

In selecting a site for the erection of storage-tanks, several points must be carefully considered, viz.:

(*a*) Position as regards water-frontage, either suitable for the accommodation of the largest ships, or, if this cannot be obtained, and the vessels require to lie in a dock not adjoining the site,

facilities for the laying of a pipe-line from ship's berth to storage-tanks.

(*b*) The nature of the surrounding neighbourhood as regards danger from fire, and the requirements and restrictions of Local Authorities.

(*c*) The means of communication by road, rail or water.

(*d*) The nature of the ground upon which tanks are to be placed, as to its suitability for foundations, and its level compared with that of the landing-place. It is always well to secure ample area, as it is generally found that more storage room is eventually required than is anticipated at the start. Upon the care and judgment exercised in the selection of a site often depends the success or otherwise of the installation, and time is well spent in careful investigation. Sometimes it is found impossible to obtain all the desired conditions, in which case special means must be taken to overcome as far as possible the natural difficulties.

In the first place the tanks should be placed in positions where their presence will not interfere with the operations to be carried on, and they must be surrounded by a bank or concrete wall, the height of which must be in such proportion to the area enclosed that the cubic capacity of the space enclosed shall be not less than 5 % above the total capacity of the tankage erected within it. This is a precaution against the event of the tanks bursting, and thereby allowing oil to escape and flood the surrounding district. An entrance to this space must be provided for by steps carried over the banks or walls. It is also advisable to fit a suction from this area to deal with any oil which may accidentally escape from the tankage. In connection with this, similar means must be provided to avoid any accumulation of water in the space, as a tank of 90 feet in diameter will float, when empty, in less than 12 inches of water, and such an event would entail fracture of the valve- and pipe-connections.

In storages where a barrelling trade is carried on, and conditions of ground permit, it is advisable so to design the surface drainage that it is led to a cement-lined sump, from which any oil which has escaped by leakage can be recovered, and not allowed to find its way into the general drainage.

Standards with swing-pipes or hose are required alongside the railway sidings for the rapid filling of rail tank-wagons, and sidings of ample length should be provided in order to deal with several wagons at once. The same class of standard is also required alongside roadways in positions where road tank-wagons can be loaded. These standards are supplied from storage-tanks either by

gravitation or pumping, and if two or more classes of oil are to be dealt with, separate pipe-lines should be provided for each. A weighbridge is also a desirable fitting.

One or more steam-boilers will be required. It may at first sight appear that boiler-fires would prove dangerous, but if proper precautions are taken, there does not seem to be much risk of this. Moreover they are a necessity, for even if all pumps are operated electrically, steam is required for dealing with the preparation of barrels, for the heating of heavy oils, and for the supply of steam to tank-vessels when discharging spirit, at which time no fires or lights other than electrical are allowed on steamers: there must therefore be considerable boiler-power provided, in order to supply steam to ships' pumps for the rapid discharge of cargo. The boiler-house should be placed as near the landing-place as convenient, and at the same time as far from tanks and sheds as possible, and it should have no windows or doors facing the tanks or sheds. The boiler-house should be of brick or concrete, and the entrance doorway should have a coaming at least 3 feet 6 inches in height, with steps on either side, or preferably the building may be raised altogether above the general ground-level, so that no oil-vapour (which is heavier than air) can easily flow to the fires.

The filling-sheds should be placed near sidings and roads, with loading platforms alongside. The floor of sheds and loading-stages should be raised to the level of a railway truck or road van. If a large number of barrels require handling, elevators to deal with them are advisable, the endless-chain type being the most convenient form; these combined with inclined barrel-runs will prove an economy in labour.

Electric light alone is of course allowable. If the current has to be generated on the premises, the dynamo and engine should be accommodated in a separate house of brick or concrete, close to the boiler-house.

II.—Foundations and Construction of Storage Tanks.

Foundations.—When selecting the site for erection of tanks, the ground should be carefully tested by weighting, or by sinking pits or bore-holes to ascertain its weight-bearing condition, and if this proves satisfactory, there is no better method of preparing foundation than by removing the soil, &c., and filling in with clean ballast or sand, forming a raised bed about 10 inches above the level of the surrounding ground. This bed should be about 6 feet greater in diameter than that of the tank, and from 4 to 7 inches higher in the

centre than at the circumference, according to the diameter of the tank and the nature of the ground.

In some cases the character of the ground is such that it is necessary to resort to piling over the whole space to be occupied by the tank, in others a ring of sheet piling is driven into solid ground, which prevents the soft material from being squeezed out. The placing of the tank on a raft about 10 feet larger in diameter, constructed of heavy baulks of timber with stout decking, has proved satisfactory in some cases. Reinforced concrete has also been used. Solid concrete foundations should be avoided, as cement is liable to break up and damage the bottom of the tank, and it also adds an additional weight to be borne. Brushwood and faggots have also been used to reinforce ground. Tanks in some cases erected on very soft soil have been known to sink some feet into it. In several cases a light steel disc has been laid on the foundation, and between this and the tank-bottom a platform of tarred wood three-quarters of an inch thick has been inserted, and has given excellent results, especially where foundations have been made up of ashes and refuse containing acid or other chemically active matter. On hard rock foundations a layer of wood is also a useful precaution against damage to rivet-heads.

Construction of Tanks.—Although in some of the earlier storages rectangular tanks were either built or adapted for the reception of oil, the cylindrical tank is now universally used, being the most convenient and cheapest form of containing vessel. They range in diameter from 20 feet or smaller, to 90 or 100 feet, with a height generally of 30 to 37 feet. A diameter of 90 feet by 35 feet 6 inches in height is a very usual size, and holds 1,387,640 gallons.

The bottom of the tank should in no case be less than $\frac{3}{8}$-inch in thickness, although the writer is well aware that many tanks are built with thinner plating in this part. The sides are built in a series of rings or strakes of plating, thickest on the bottom strake, and gradually becoming thinner towards the top. The thickness of this plating varies, of course, with diameter and height of tank.

A small pocket or well is sometimes fitted in the bottom of the tank, to which is attached a pipe for drawing off water, but the advantage of this is doubtful, and moreover it introduces an element of danger through accidental or wilful damage to the pipe.

The attachment of the bottom to the lowest strake of plating is made by an angle bar, double-rivetted both to bottom and side.

The seams of the bottom plating and horizontal seams of the side plating are single-rivetted; the vertical side seams are treble- and double-rivetted.

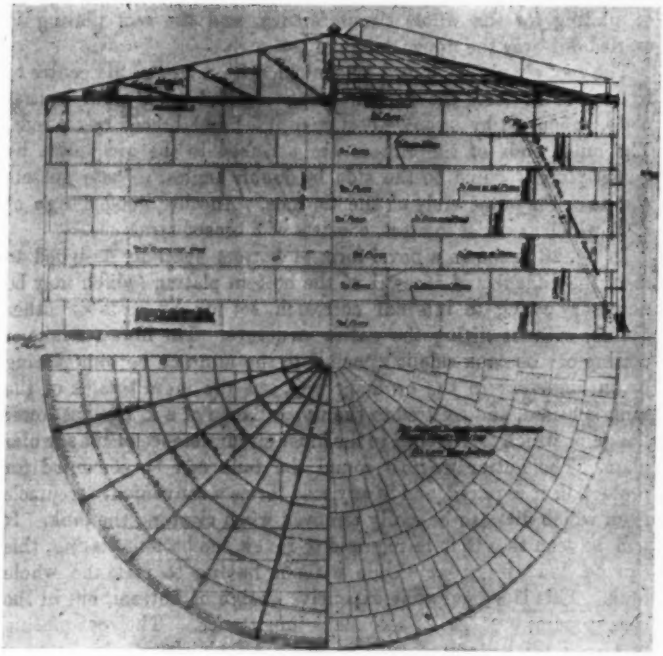

FIG. 22.—Fuel-Oil Storage Tank, 90′ diam., 36′ 6″ deep.

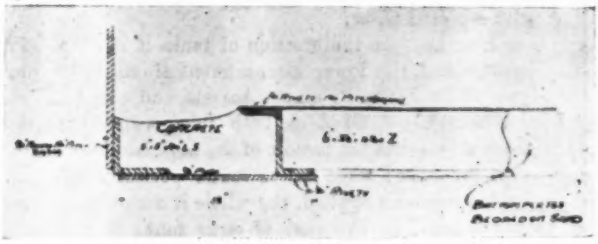

FIG. 23.—Patent Tank-bottom.

We regret that the reduction of the illustrations to the size of our pages renders some dimensions, etc., illegible.—ED.

An angle curb is single-rivetted to the upper edge of the top tier of plating for the whole circumference, and the roof plating is carried out over the upper flange of the curb.

The roof should be domed or conical, with a rise at the centre of from 3 to 10 feet, the rafters being rivetted to a stout centre-plate, supported by a centre-post suspended and braced by tie-rods. The outer ends of the rafters are attached to the top strake by gusset plates secured to the side by double angles. These gussets also take the outer ends of the tie-rods. Another good design of roof, which is easier to erect, consists of a braced structure.

In fig. 23 is shown a novel form of bottom specially designed to meet the difficulty of renewal of the bottom plating (which may be necessary owing to internal corrosion set up by acids or other causes) without lifting the entire structure. The lowest strake of plating of the tank-side is attached to the annular bottom plating by an angle-bar in the ordinary way, but the main bottom of the tank is raised, and rivetted to the upper flange of a Z bar, the lower flange of which is attached to the inner circumference of the annular plate. The gutter way all round the tank can be cemented for protection if required, and in any case forms a convenient receptacle from which dirt can be easily removed when cleaning the tank. It will be seen that if it is required to renew the bottom plating, this can be done from the inside without having to raise the whole tank. This is a somewhat expensive design of bottom, but in the case in point cost was of secondary importance. The roof-plating is $\frac{1}{4}$-inch thick, jointed with tapering $\frac{1}{4}$-inch rivets. It is good practice to galvanise these roof-sheets, especially for tanks on the sea coast. There should be four manholes in the roof, with hinged covers, provided with locks, and a centre-hole for ventilator and dipping. A manhole should also be fitted on the lowest tier of plating, with a bolted cover.

Method of Erection.—In the erection of tanks it is usual to rivet up the bottom and the lower circumferential strake of plating whilst supported on blocks or empty barrels, and when the seams have been thoroughly caulked on both sides, water is run in to a depth of about a foot, and the bottom of the tank carefully examined from beneath for leaks; when all is found perfectly tight, and a good coat of tar has been applied, the whole is carefully lowered on to the prepared bed. In the case of large tanks it is sometimes necessary to brace the bottom during this operation to prevent any sagging which might start the caulking. The remaining strakes and top curb are then erected and rivetted up, and all landing edges caulked inside and out, the rafters erected in place, the

roof plated and rivetted up, and internal fittings, if any, fixed in position. As walking on the domed or conical roof of a tank is somewhat dangerous, especially when wet or under snow, stanchions, firmly bolted to the upper curb, and carrying hand-rails, should be provided all round the outer edge of the roof, the bottom rail being placed low enough to prevent a man slipping under it. Hand-rails should also lead from the centre of the top to each of the four manholes for protection when using the centre diphole. At least one iron ladder should be fitted from the ground to the top, outside, and one from a manhole to the bottom of the tank inside. Lightning conductors are sometimes fitted, but if hand-rail stanchions and rails have good metallic connections to the tank, they give a certain amount of protection: still it is advisable to "earth" the side of the tank with a stout copper conductor, especially where a wooden disc is fitted under the bottom. In most of the earlier tanks gauge-glasses were fitted in overlapping sets from top to bottom of tanks, but these were not found to give a correct reading of the height of oil in the tank, and are now seldom fitted. As tanks are frequently out of plumb, to get a correct reading, glasses would be required to be fitted in four positions around the tank. Moreover if gauges are exposed to heat of the sun's rays, the oil contained in them becomes heated and expands, but of course does not increase in weight, and therefore the surface of oil in the glass stands above that in the tank, and if the attendant fails to run the oil from the gauge and allow it to refill, a false reading may be obtained.

Testing.—On completion of the tank, and before any painting is done, it should be filled with water, and any leaks made good. In the case of a serious leak, it is best to mark it, and caulk it after the water has been run out. The water should be allowed to remain in the tank for some days, in order to consolidate the foundation before finally coupling-up the pipe-connections; a length of flexible hose can be fitted for coupling-up, should it be required to use the main pipe-line for filling the tank. A careful record should be kept of any settlement or other movement of the tank.

After the tank has been in use for some months, a cement water-channel should be constructed all round the base of the tank, with connection to drain, and an asphalt-joint should be made between this channel and the bottom edge of the tank, as it is most important for the preservation of the under side of the bottom that no air should be allowed to gain access. Tanks should be left unpainted until the mill-scale has been removed by rusting. No painting is required internally.

In the case of storage of heavy viscous oils, it is necessary to provide for heating of the oil in the tanks, in order to facilitate delivery, as otherwise in cold weather it may be found impossible to run or pump the oil out. This heating is generally arranged by fitting piping, led backwards and forwards across the bottom of the tank, as low down as possible, the pipes being secured with clips and supports. Steam is supplied from the boiler on wharf through valves on the outside of the tank, and the drains controlled by a steam-trap to avoid waste. In large tanks it is often advisable to divide the piping into sections, each having a direct supply of steam and a separate drain.

In some of the large tanks designed for the storage of petroleum spirit, the roof has been made gas-tight, pipes being led from a position above the highest level of the spirit to a condenser arranged in the form of a water-sealed gasholder. This receives the gas and air flowing from the tank during the filling, and any gas given off in warm weather, the gas being condensed at night, and the spirit, as collected, pumped back into the main storage-tank. It has however been found that in temperate climates the results hardly warrant the expenditure. In addition to water-cooled roofs, there are many installations in tropical or semi-tropical climates where light walls, of considerable height, are built round the tanks to provide a shade for the sides. It may be mentioned that in many of the earlier tanks erected in this country American methods were adopted, and it was thought necessary to provide a flat roof with shallow edging, in order that some inches of water could always be carried on the top to keep the contents of the tank cool during the summer weather. This flat roof, together with the weight of water, of course required support, and some tanks contained a small forest of wooden posts, the lower ends of which rested on the bottom plating. These posts displaced quite an appreciable amount of oil, and constituted a very clumsy arrangement. Self-supporting roofs were therefore designed, and some very fine tanks were built, but the cost was high, and gradually it was found by experience that it was unnecessary to provide for a water-cooled roof in this country.

With some of the first domed or conical roofs a centre pillar was introduced as a support, bolted to the bottom of the tank, and fitted with long studs at the top to slide through holes in the roof, but these in some cases jammed, and the movement of the bottom, when the tank was filled, pulled down the roof, and caused considerable damage. The self-supporting, braced roof of curved or conical form is now generally adopted.

A somewhat unusual arrangement for storage is that adopted by

a firm in the Midlands, which consists of several rectangular tanks, some of them upwards of 85 feet in length by 17 feet in breadth, built into caves excavated in the rock, but there are several disadvantages in such a position, although a very equable temperature is maintained.

Gauging of Tanks.—As it is most important that the actual capacity of storage-tanks should be known, the accurate calibration of large tanks requires the greatest care. After a new tank is completed, and all water-tests made, the tank is carefully measured with steel tapes both for diameter and circumference, a good many measurements being taken in all. The displacement of any fittings inside the tank has also to be calculated, and from these particulars the capacity per inch of height is worked out. The writer has been associated with this work from the commencement of bulk-transport, and has carried out careful experiments with steel-tape measures, in order to construct formulæ for dealing with sag and stretching of the tape.

In connection with the gauging of tanks, a few words may be said in reference to the method of ascertaining the quantity of oil in a storage-tank. In the first place it must be ascertained whether the tank contains any water on the bottom below the oil, and it may be mentioned that in cases where the bottom of the tank is uneven, water is often introduced to form a base from which to measure, and in others, where leaks are suspected out of sight in the bottom of the tank, water is kept on the bottom, so that any leakage may be of water, and not of oil.

The presence and depth of water is ascertained by an apparatus consisting of a sinker weight carrying a strip of paper chemically prepared so that the paper is acted upon by water but not by oil. This is lowered to the bottom of the tank in, preferably, five or more positions, and on withdrawal registers by its discoloration the depth of water lying on the bottom. Dippings are made in the same positions by a weight attached to a steel tape-measure. In dipping heavy viscous oil it is advisable to use a pointed weight. The exact depth of oil is read off on the tape in the several positions of dip, and an average taken. By ascertaining at the same time the temperature and specific gravity of the oil, and deducting the registered amount of water, the actual weight of oil present can be calculated from the figures obtained in the gauging of the tank.

Details of Machinery for Reception and Delivery.

Pipe-lines and connections.—It is a good practice to fit an internal swing-pipe inside the tank, working in a packed-socket, with a

flange connected to the side of the tank by means of a distance-piece to a valve fitted outside the tank: this arrangement allows the other end of the pipe to be raised or lowered to any required

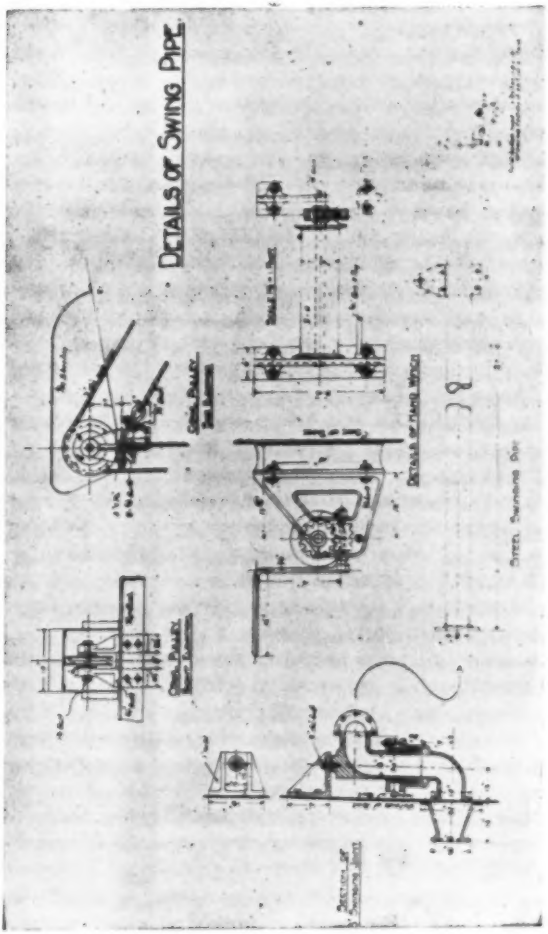

FIG. 24.—Swing-pipe.

position, or hauled up above the level of the oil, the movement being effected by a worm-driven winch and a wire passed over the upper edge of the tank.

This enables oil to be drawn off from any level in the tank, and is also a safeguard in the case of accident to the external valve or pipe, when the orifice of the swing-pipe can be raised above the level of the oil, thus preventing loss. Fig. 24 shows a design with joint so arranged that the outside valve can be overhauled or removed, if required, whilst the tank is full of oil; as when the swing-pipe is hauled up to its highest position, no oil can escape. It is necessary to fit a guard over the open end of the swing-pipe to prevent the disturbance of any water or dirt lying at the bottom of

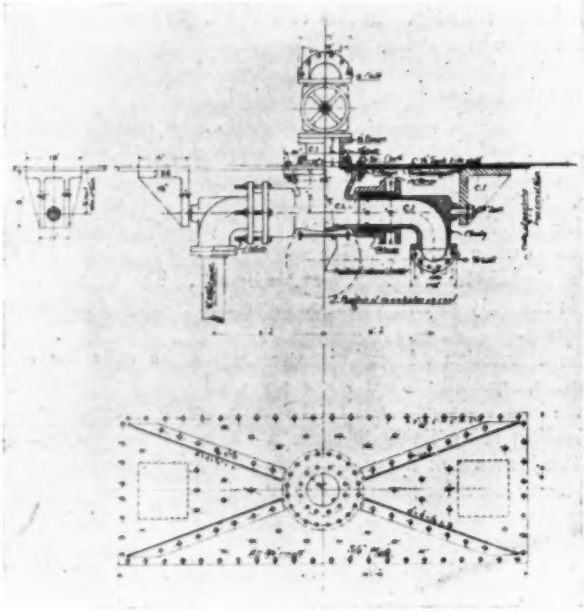

FIG. 25.—Details of double Swing-pipe.

the tank when only a few feet of oil remain. A cylindrical cap of about three times the diameter of the suction-pipe, closed at bottom and open at top, and secured to the end of the pipe, is found effective, as the oil flows over the upper edge of the cap to reach the suction, preventing any direct upward flow. For heavy oils a heating-coil, supplied with steam by a flexible metallic tube, should be fitted on the end of the swing-pipe.

In some cases a drop-valve is fitted internally, operated by a fine

wire-rope in order to shut off oil, but should this leak, or an obstruction lodge under it, it becomes useless. The practice of carrying the inlet-piping up to the top of the tank outside, and down to the bottom inside, is sometimes adopted, but this involves the fitting of another connection at the lower part of the tank for drawing off.

In connection with internal swing-pipes, an incident may be related which occurred during the construction of a storage-installation for which the author was responsible. As often happens, the completion of a tank or tanks had to be greatly hurried in order to be ready for the cargo on arrival of a tank-vessel, and save detention of the ship. In this case the tanks were finished, with the exception of a swing-pipe in one of them, which had not been delivered, although the socket-joint inside the tank was in position.

After the tank had been filled with ordinary burning oil, and the pipe had arrived, a diver was procured, who agreed to descend through one of the manholes in the roof, and bolt on the pipe to the socket, which was situated about three feet from the bottom of the tank. This work he carried out successfully, his only remark on coming out being that he felt the cold on his hands more than was usual when working under water, and that he missed the noise of the air-bubbles escaping from his helmet. The author believes this is the only case in which a diver has descended in 30 feet of petroleum.

The connection of piping to storage-tanks calls for careful attention, especially when tanks are erected on soft or unsettled foundations, the movement of the tank under different conditions of loading being liable to cause a strain on the piping, and a possible breakage of it or of valves. Various methods have been adopted to allow for this movement.

(*a*) An arrangement of elbows so designed that any movement will be taken up at the screwed joints.

(*b*) A coil construction; in which case all joints are dispensed with, and there being no sharp angles the flow of oil is not impeded. The spring of the pipe alone is relied on to deal with any movement of the tank.

(*c*) Copper connecting-bends have been used, but these are expensive, and liable to develop leaks; also the metal is, in some cases, affected by certain classes of oil.

(*d*) Flexible hose is sometimes employed where permanent connection is not desirable.

The main delivery-pipe leading from the position of the ship's discharge to the storage-tanks should be designed of a large diameter, and in some cases consists of two or more distinct lines.

This is absolutely necessary when different classes of oils are stored. A pipe of large diameter greatly facilitates the rapid transfer of oil, and relieves pressure on the ship's pumps and connecting hose; in fact, all piping should be of ample size. A non-return valve with gear for lifting the valve when required, should be fitted at the wharf end of the pipe-line. In the case of heavy viscous oil, which is delivered hot from the ship, it is necessary if the pipe-line is of any considerable length, to provide for the heating and keeping hot of the oil during its passage through the pipe-line to the tanks. This can be done by running a steam-pipe inside the oil-pipe, and providing a satisfactory lagging outside: but with this method there is the danger of the steam-pipe breaking or leaking, making it necessary to break joints for repair.

Another method, which overcomes this disadvantage, and has given good results, is to run one or two steam-pipes outside the main oil line, clipped to the lower side, and covered with a sheet-iron guard carried half-way round the main pipe and wired to it, the whole being covered with good non-conducting lagging. Hot water, with mechanical circulation from the boiler on the wharf, can be used instead of steam if desired.

In pipe-lines of considerable length, when exposed to the action of the sun, it is well to provide a relief-valve fitted in a convenient position on the line, as it has been found that when the line has been left full, and the valves closed, the heating of the oil by the sun's rays has caused a very high pressure, owing to the expansion of the oil.

All pipes should be kept above ground where possible, supported at intervals on cement-blocks, but in no case rigidly fixed, except possibly at certain points where an easy bend is arranged to take all movement arising from expansion and contraction. Packed expansion-sockets should be avoided, as they are difficult to keep tight, but if the length of straight pipe is considerable it is advisable to fit a steel expansion-bend of the standard loop type. The material for pipes should be mild steel, lap-welded, and joints should be made by screwed sockets. Flanges should be avoided as much as possible, except at the junction of fittings, and where the line is liable to require breaking for future extensions, &c. It is advisable, especially in the case of long pipe-lines, to provide an air-pump and receiver for the purpose of emptying the pipe-lines after discharge or loading of a cargo, before the next consignment is dealt with, particularly where this consists of a different class of oil.

Pumps.—When possible, installations are arranged so that the

ship's pumps discharge direct to the tanks, but in cases where the shore tanks stand at a high elevation, or at a long distance from the ship's berth, it is necessary to provide pumps on shore, as near the ship as convenient, to deal with the extra pressure required in pumping. These pumps should be arranged with bye-passes to reverse, so that they can be employed for delivering when required. In cases where shore pumps are employed for the above reasons, the ship's pumps generally discharge to a central receiver, the high-pressure pumps drawing from this, and delivering into storage-tanks, at speeds governed by the amount of oil received from the ship.

Pumps are driven by steam, electricity, or sometimes, when dealing with spirit, compressed air, according to requirements. Smaller pumps are of course required in considerable numbers in a large installation to deal with deliveries, transfer from tank to tank, &c.

Generally, when steam- or air-driven, the direct-acting duplex or simplex pump has been found the best type for these purposes. When electrical power or internal-combustion engines are used, the 3-throw geared pump has been found the most convenient form.

Valves.—The full passage throughway gate-valve is almost universally used, and gives good results. Valve and seat should be brass-faced, and, if fitted with an internal screw, an index should be provided to show position of valve. Flange-joints are best made with compressed paper, and when spirit is to be handled, red fibre makes the best joint for flanges, litharge being used on screwed joints.

Filters.—When dealing with fuel-oil it is generally required that the oil should be filtered during its passage from ship to tank, and also again when being delivered for use. The types of filters used vary considerably in design, wire-gauze being used as the filtering medium. Fig. 26 shows a set specially designed for dealing rapidly with large quantities of fuel-oil. It will be noticed that they are in duplicate, and facilities are provided for easy cleaning, one unit being sufficiently large to deal with the maximum delivery required, and thus allowing them to be alternately cleaned. In designing a filter, care must be taken to allow sufficient area through the gauze in order to avoid setting up too great a pressure in the pipe-line. The filtering medium must also be well supported to prevent breakage, and the flow of oil should strike the gauze wire diagonally, and not at right angles, so that the dirt is not held against the mesh.

Precautions against fire.—A good installation of water-supply and distribution should be fitted in connection with all storages, as,

although in the case of oil igniting in the tanks, this is of little use beyond keeping the sides of the tanks cool, fires generally originate in the buildings on the ground. Sand boxes with shovels should be provided at several points.

A method of dealing with oil, when ignited in tanks, appears to possess some advantages. In this system a mixture of soda, sulphate of alumina and licorice is stored in a vessel or vessels attached to the under side of the roof above the level of the oil, and on a fire originating this is automatically discharged, together with water, on to the surface of the burning oil, the effect being that a froth or scum is produced, of several inches in thickness, the gas contained in the froth immediately quenching the flame. Some satisfactory tests appear to have been made with this apparatus.

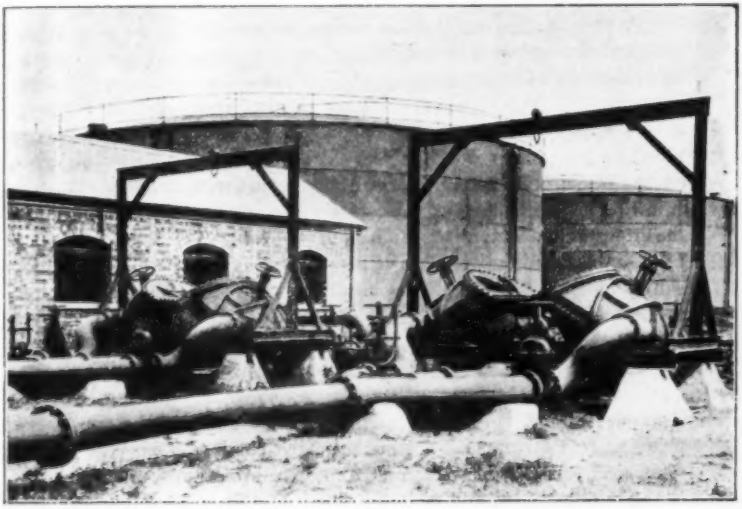

FIG. 26.—Fuel-oil Filter.

GENERAL FEATURES OF INSTALLATIONS.

Having dealt with the constructive details of an installation, I had hoped to describe some of the principal storages in this country in detail, but under the present conditions I am advised that no names or localities must be mentioned; so I propose to allude to some of the features existing, and to say simply "somewhere in the United Kingdom."

It may be of interest to mention one of the earlier installations erected in this country, where special difficulties as to site had to be dealt with. This storage being on a river which is not navigable for sea-going vessels, all oil has to be conveyed to tanks by means of barges. At that time there were no specially constructed steel tank barges designed for this work, as there are now. Wooden barges had therefore to be employed, fitted with steel tanks, and after a cargo was delivered, the tanks, two in each barge, were lifted out by a crane erected for the purpose, and stored on the wharf until again required, the barges being thus liberated for other work. The space available for the storage of tanks being limited, and the crane for lifting being for the same reason in a fixed position, a special trolley was designed for transporting tanks, with the table capable of being raised and lowered by screws. The tanks being lifted out of the barge, and lowered on to the trolley with the table in a raised position, the trolley was then run between supporting blocks, the table lowered, and the tank deposited on the blocks, then the trolley was withdrawn, and other tanks dealt with in the same manner until all were neatly packed close together. When the tanks were again required, the process was reversed. A large steam-pump was fitted on the wharf side, which pumped out the tanks with flexible hose from barges alongside. Extensive sheds were erected to deal with the preparation and filling of barrels, the handling of empty and full barrels being carried out expeditiously by the use of inclined runs and endless-chain elevators. There are still many storages where oil has to be brought by barges, but it will be seen that the system presents many inconveniences.

As regards modern installations, there are a great number well equipped, some of them connected to the ships' discharging berths by pipe-lines of considerable length, and in which the general principles of design as set out in the earlier portion of this paper are embodied, but as I am debarred from describing them in detail, all that could be said would be but a repetition of that already set out.

In the case of installations for the storage and delivery of liquid fuel, it may be mentioned that in many cases rapid delivery is a most important function. Pipe-lines are therefore designed of exceptional size, and powerful pumps are generally fitted in close proximity to the tanks, with very large suction-pipes in order to secure the delivery of large quantities of oil under high pressure to various points simultaneously. This is of special importance in Admiralty work, with which the author has been closely associated, and it is with great regret he is unable to give some interesting information relating thereto.

Owing to the restrictions placed upon the discharge of vessels carrying petroleum spirit in bulk, and their being allowed to carry out this work only at certain places, it is often necessary to convey spirit in barges or rail-wagons from large bulk-storages to smaller depôts, where the process of canning, &c., and delivery can be more conveniently carried out. These depots are often placed in a populated district, where local requirements, generally very severe, have to be complied with, and special precautions taken against fire, in consequence of the highly inflammable nature of the product, and without describing any particular depot, it may be of interest to mention some of the principal features that it is advisable to embody in the design.

Petrol storage.—The number of storage-tanks is of course fixed by deliveries obtainable from bulk and the requirements of the trade, and they should not be of very large capacity. Nine feet in diameter by thirty feet in length is a convenient size. They should be buried in a horizontal position below the surface, and covered with concrete. This position necessitates the pumping of all spirit, for none can be run out by gravitation, as all the canning sheds and arrangements for delivery are above ground.

Where a wharf can be obtained, it is of great advantage, as it furnishes accommodation for tank-barges, by which all spirit can be delivered to the premises. These tank-barges also require to be pumped out, and the spirit delivered into the underground storage-tanks, and pumps are required for this purpose. All pumps should be duplex, driven by compressed air. The air-compressor is best placed in an isolated room, on a floor about 8 feet above ground, delivering into a large reservoir placed below; the electrical motor must be automatically controlled in order to maintain a pressure in the reservoir varying from 30 to 60 lbs. per square inch. This latitude is arranged to give as few stops and starts for the motor as possible. All pumps are supplied from this air-reservoir, and should also be automatically governed. The service-tanks in the canning shed should be fitted with gauge-glasses in full view of the operator, and the pumps supplying them must be controlled from this position, the air-main being run through this building, and the pumps placed at some distance in a separate house. The overflows from the canning machines and service-tanks of both spirit and gas must be carried back to the main storage-tanks, and the ventilation of these tanks provided for by pipes carried up some 15 to 20 feet above the level of the ground.

The pumps should be placed in a separate house, together with a large distributing box fitted with valves, to which all

piping is led, so that all operations can be controlled from this central station.

It is necessary to lay all piping underground, in concrete trenches filled in with sand covered by a half-inch layer of cement, and this again covered by iron chequer plate. The jointing of piping and flanges, which is always a difficult matter with spirit, should be carried out with red fibre and litharge, which has given excellent results. It is necessary to provide a large canning house with a floor raised above the level of the ground to facilitate the delivery of spirit in tins, and below this floor a concrete chamber, closed with iron doors, can be provided for the storage of full tins.

Sheds for cleaning, painting and storing empty tins are also required, all these buildings being served by a light trolley way. Standards for filling road or rail tank-wagons will be required. It may also be required to provide for the retail delivery of spirit to road-motors. This will necessitate the provision of means for carefully measuring spirit in closed vessels before delivery. The yard should be covered by iron roofing, under which vehicles can stand whilst taking in supplies. All drainage from the ground must be carried to a sump fitted with a special separator and iron cover, so that by a periodical inspection of the contents any escape of spirit can be at once detected, the separator preventing any from passing into the general drainage system.

Special precautions must be taken when lighting buildings where spirit is being handled, and it is advisable to allow no lights, wiring, switches or fuses inside the houses, and to fix the lamps, fitted with reflectors, outside the windows, so that light is directed to the desired position.

Lubricating oil.—The storage of lubricating oil in bulk has now developed to a considerable extent, and in cases where this is dealt with, the oil is stored in ordinary tanks of medium size, but, before delivery, in order to secure a clear bright oil, it is occasionally necessary to eliminate any water which may be held in suspension, and which renders the oil cloudy. This is most efficiently and expeditiously done by heating the oil in a special tank, fitted with heating-coils and means for introducing heated compressed air through perforated pipes arranged at the bottom of the vessel, so that the heated air, rising in bubbles, absorbs any moisture contained in the oil, and discharges it on the surface in the form of steam. When so treated and cooled down, the oil is found to be perfectly clear and bright. Blending of lubricating oil can also be carried out with the same apparatus, as the passage of the compressed air violently agitates the oil, and insures a perfect mixture.

This process is also carried out in some cases by a mechanical revolving agitator fitted in the treating tank.

Subaqueous storage.—A new and interesting development in the direction of oil-storage is that devised by Messrs. Doxford, of Sunderland, who have constructed a model, and made careful experiments connected with the problems of ballasting and trim involved. Their design consists in providing a subaqueous storage for oil where the containing vessels would be safe from bombardment either by guns on land, air-craft or submarines, and possesses very valuable features in this and other directions. One design consists of a cylindrical vessel having hemispherical ends and internal dividing bulkheads of dished form in order to minimise weight as far as possible. Arrangements for mooring and towing are fitted.

Messrs. Doxford have suggested as a convenient size of tank a vessel 150 feet in length and 30 feet in diameter. This would carry a deadweight of about 2,400 tons of liquid fuel, and could be submerged in any reasonable depth of water, a ballasting compartment being arranged at each end. The joint capacity of these two compartments is somewhat in excess of the reserve buoyancy when the vessel is fully loaded, and in this case would be about 150 tons, viz., 30 tons in excess of the reserve, so that if required the vessel can be sunk to the bottom of a harbour. Each oil compartment has three connections led to the valve-room, one for ballasting, one for dealing with oil, and one for the expulsion or admission of air. This connection can also be used for the admission of compressed air, when this is employed as the means of discharge. The ballast-tanks have connections to deal with water. The submersion of the vessel can of course be carried out without any attendant power-craft, but to bring her to the surface, compressed air must be supplied from an auxiliary vessel, in order to force out the ballasting water. The expulsion of a little over 30 tons in this case would bring the vessel to the surface. If compressed air is not available, and the barge is not lying in too great a depth of water, oil or water can be pumped out by flexible hose until she rises, a second hose being provided to admit air.

When it is required that the barge should remain on the bottom, the ballast-valves are opened, and water allowed to enter and take the place of the oil pumped out. Under these conditions water must come in direct contact with oil, but by fitting the sea-valves and pump-suctions well apart, and introducing baffle-plates in the way of the pump-suctions, any disturbance of the oil immediately in contact with the water, and possible mixing, is avoided.

Messrs. Doxford have designed a very large vessel, the dimensions

being 450 feet in length by 50 feet 9 inches mean diameter, capable of containing 20,000 tons of oil at 39 cubic feet to the ton. This is designed on the Jack-Doxford balanced-pressure system, and is

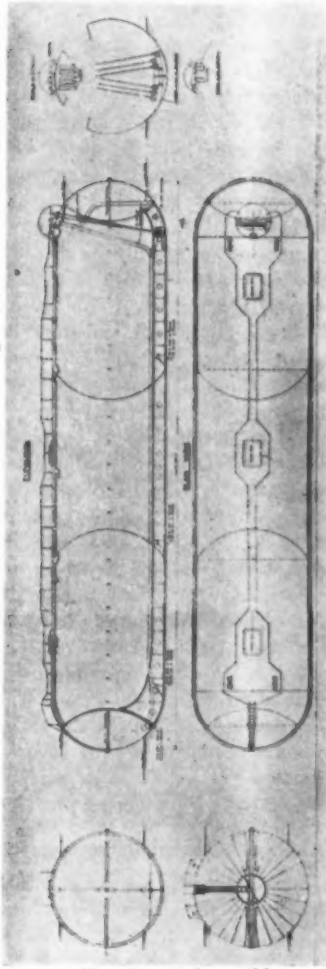

FIG. 27.—Submersible Oil-tank.

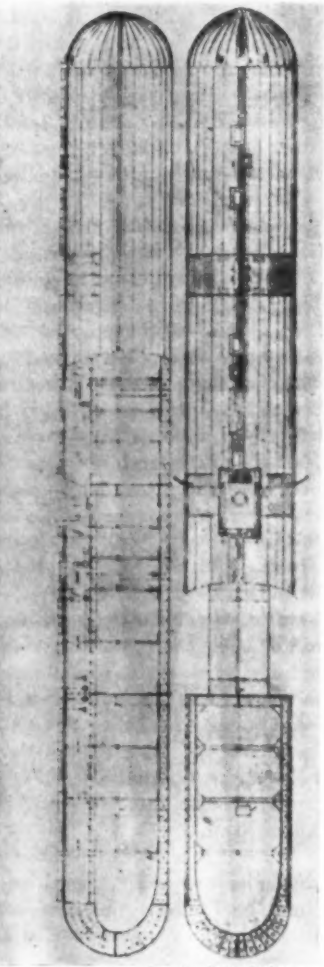

FIG. 28.—Doxford 20,000-ton Submersible.

intended to remain always afloat, moored in a harbour; as the oil is pumped out, water takes its place so that instead of the barge

rising in the water during discharge, it gradually sinks, and when all oil is discharged is immersed to a somewhat greater extent in proportion to the difference in weight between the oil and water, but will within a small margin always float at its loaded draught. The channel in the centre running the whole length of the structure

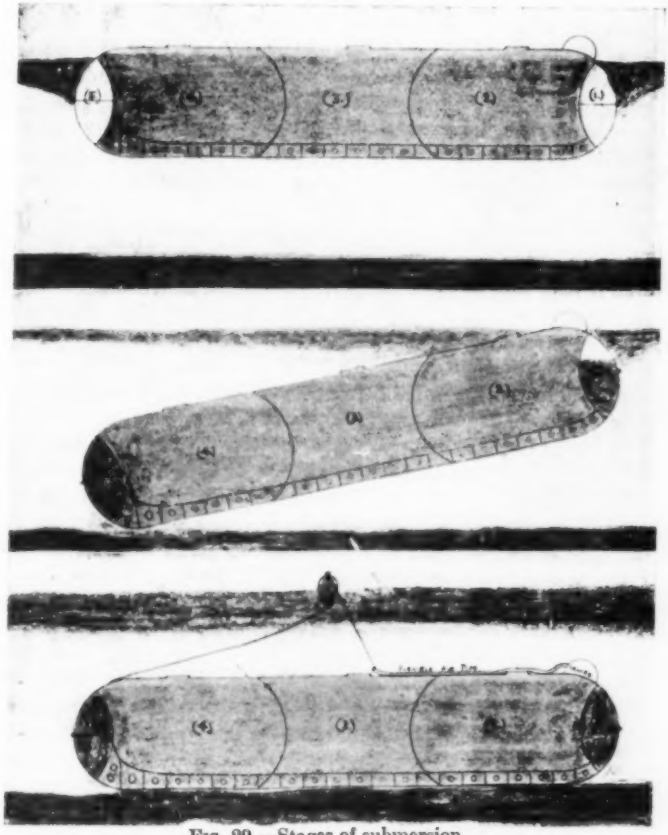

FIG. 29.—Stages of submersion.

provides the reserve buoyancy, and from this space all valves can be operated.

By this arrangement practically all bending moments in the structure are eliminated. Moreover, at no time is there any great pressure on the cylindrical vessel. The stability of the vessel is

secured by ballasting with pig-iron and cement. Should it be required to heat the oil in the vessel in order to facilitate pumping, this can be done by fitting steam-coils around the suction-pipe in the trunk, and also, if necessary, by steam-pipes led along the crown of the tank on each side.

It will be noticed in the submersible type that this arrangement, in addition to providing absolute safety from a military point of view, may be equally valuable from a commercial standpoint. Both the submersible and non-submersible tank or barge, being movable, can be brought alongside a vessel if required. A storage on these lines can be provided in a port where there is no ground in proximity to the sea available for an installation on shore. Doubtless with the increasing use of liquid fuel on board ship, either for raising steam or for internal-combustion engines, many more stations will be required where fuel can be obtained. The subaqueous storage offers a method of providing these facilities, even if only adopted as a temporary means, which could be completed and in working order, in a much shorter time than that required to arrange land, pipe-lines, &c., and erect tanks on shore, the only requirements being a sheltered spot to moor the barge, and a suitable bottom on which the vessel can rest, should it be required to totally submerge her.

In most cases it would also prove the cheaper method, when cost or rent of land, together with expense of pipe-lines and wharf-accommodation, are taken into account. Interesting experiments are now in progress with the idea of adapting cylindrical vessels of this type so that they can be towed safely on ocean voyages.

In conclusion it may be pointed out that fires occur at times in oil storages, but generally when a tank of oil becomes ignited the oil burns only on the surface, gradually melting away the plates above the level of the oil as the contents are consumed, until the whole is burnt out and the tank entirely destroyed.

I have much pleasure in acknowledging with thanks, photographs and plans from Messrs. Doxford, and from the Whessoe Foundry Co.

DISCUSSION.

The President, in opening the discussion, remarked that the paper might be regarded as complementary to the equally valuable one on the Evolution of the Tank Ship contributed to the Institution by the author in May, 1915. On the present occasion, as on the former, the statements made were those of a master of his subject, for the author had had such a lengthy and wide experience that he was entitled to speak with authority.

He thought it would be conceded that probably the general interest in the present paper centred round two or three paragraphs, in which reference was made to the consideration which was being given to the construction of storage vessels of large size of the form indicated which could be towed across the Atlantic. It was now, he thought, some ten years since the Standard Oil Company made an experiment in towing one of their barges, known as Barge No. 95, across the Atlantic from the United States to this country, with a cargo of 6,000 tons of gas oil.

The experiment was so successful that subsequently the tank steamer "Iroquois," belonging to that Company, besides bringing the usual cargo of petroleum products, regularly towed across the Atlantic the barge "Navahoe," laden with oil, and, as far as he was aware, that procedure had been continuously in operation without anything occurring tending to show that the system possessed any serious disadvantage. It might be said, therefore, that the economy of that method of transport had been conclusively established by the experience which had been gained, and, as the author had pointed out, although there were some disadvantages in towing almost wholly submerged vessels, there were, on the other hand, certain very obvious advantages connected with such a system.

He understood that it was quite evident practical experience had shown that an almost wholly submerged vessel of the kind in question could be more readily towed, i.e. towed with less strain on the towing cable and at a greater speed, than a barge of the ordinary construction. It was obvious that if such a system of transport combined with sub-aqueous storage found favour, there must be very great advantages in such a system from the military point of view, for if stores of oil could be put away out of reach of shell-fire or attack from the skies, and especially if their position could be varied from time to time, it would be a great gain in respect of safety.

The measuring of oil, which had been referred to by the author as an operation which had been brought to a state of great accuracy, had necessitated the devising of various instruments for the purpose. The determination of the depth of water at the bottom of a tank containing oil was also an operation which had needed to be specially dealt with by the construction of suitable appliances for the purpose. The earliest arrangement for measuring the depth of water at the bottom of the oil was devised by Messrs. Hawley & Sedgley.

The instrument which bore their names consisted of a vertical glass tube fixed in a frame, and provided with a sliding cap, by

means of which the lower end was closed. When the instrument was lowered through the oil and any water which the tank might contain, the tube was open at both ends, but on the sliding cap coming into contact with the bottom of the tank, the frame, which was weighted, descended; the tube was thus closed at the bottom and a sample of the liquid or liquids enclosed. But that instrument had long since been superseded by the registering water-finder devised by his brother, Mr. Robert Redwood, in consultation with the author, which depended for its action upon the change effected by water on the surface of a chemically prepared paper, upon which oil had no action. A narrow strip of the paper was attached to a graduated brass cylinder, which was lowered to the bottom of the tank, and the paper was altered in colour to a distance corresponding with the depth of the water beneath the oil.

The pointed form of weight, referred to by the author, was designed originally by his (the President's) brother, and was made by Messrs. W. J. Fraser & Co., for use in the measuring of creosote, but it had been found very suitable for use with various viscous descriptions of petroleum. Mr. H. Simmons had designed a weight or sinker, provided with an ingenious method of clipping the steel tape so as to secure accuracy of measurement.

Reference had been made to the protection of tanks from lightning. He thought it might be useful to mention that in the opinion of many experts one of the most efficient means of protecting oil tanks against lightning was to stretch across the top of the tank, at a height of a few feet above the top, a number of strands of barbed wire, well earthed and extending from a series of vertical uprights placed in the ground round the tank. Whatever precautions were taken in relation to risk of fire through lightning, it was, as a matter of general principle, desirable to suspend the discharge into storage-tanks of petroleum spirit, or any highly-inflammable description of petroleum products, during a thunderstorm, and it was important to bear in mind that when petroleum spirit was being discharged from the end of a pipe into a tank, such a disturbance of electrical equilibrium was liable to be caused as might result in disruptive discharge or sparking, and consequently in ignition of the oil.

The only other matter to which he desired to make a brief allusion was the storage of motor-spirit. The needs of the omnibus and cab companies, and of commercial firms and of private individuals who used motor vehicles, had led to the necessity of storage of large quantities of motor-spirit in populous centres, where a few years ago it certainly would not have been possible to procure

permission for such storage. The system which appeared to commend itself in most cases to the local authorities, from whom licences to keep the spirit had to be obtained under the Petroleum Acts, was to provide an underground receptacle, from which the spirit was displaced by means of water. Complete installations on this principle were now obtainable, which were provided with automatic arrangements for guarding against the risk of water being delivered with the spirit, or of the spirit escaping into the drains.

Mr. C. Dalley thought the author was to be congratulated upon his capacity for imparting the maximum amount of information in a minimum space of time. There were two or three points upon which he desired the author's further advice. In the first place, the statement was made in the paper that the bottom of the tank should in no case be less than three-eighths of an inch thick. It appeared to him that that depended on the site of the tank, particularly under existing conditions. He desired to ask the author whether in view of the present price of steel, it would not be more economical, and probably just as satisfactory, to use thinner bottom plates, put a little more money into the foundations, and thus save overall costs.

With reference to the question of lightning conductors, provided the tank was not insulated from earth, the ordinary copper lightning conductor as now fitted might easily prove a very false security. If the tank formed a good earth with the surrounding ground, it was probably only necessary to provide a means for silent discharges from the tank. Where a tank, as was usual nowadays, possessed hand railings, the most convenient method to adopt was to lengthen every sixth handrail stanchion to a convenient height, and give it a sharp point. The problem of efficient lightning conductors and their earthing had undoubtedly received insufficient attention, and petroleum engineers were only just realising that they were working considerably in the dark on the subject.

In a later part of the paper the author mentioned that when electrical power was used, the 3-throw gear pump had been found the most convenient form. On the score of lower first cost, general adaptability and reduction of space occupied, he would have expected the author to suggest a high-speed centrifugal motor-driven pump. For general purposes he thought the centrifugal pump was as popular as any pump at the present day, particularly with low and medium lifts. The high-lift pump, with which he was fairly well acquainted, did not appear at present to find favour in the oil world, probably owing to the innate conservatism of those connected with it.

It might not be considered irrelevant to the paper if he gave an example of a pumping installation, one of several for which he was responsible, which was not pumping oil but water. The high lift, or, as it was sometimes called, the turbine pump, was an improvement on the centrifugal pump, inasmuch as there were special diffusors which took the oil or water or other liquid at a high velocity, and gradually diffused it until it came to an equivalent pressure head. In practice very big heads were dealt with, by building these pumps in stages; theoretically there was no limit to the number of stages, but for practical reasons two or more pumps were usually put in series where the head was very great. In the particular installation to which he referred there were three 6-stage pumps dealing with 88,000 gallons of water per hour against 1,650 ft. head. They ran at 1,450 revolutions a minute, and dealt with a problem of unwatering a colliery in which the water was very gritty—in fact, so gritty that one would hardly recognise it as water.

That and many other installations showed that high-lift pumps were quite practicable commercial articles, and although he had no personal experience of them in pumping oil, he saw no reason why they should not be used in many cases where reciprocating steam pumps, and other methods which were perhaps not such a good means of dealing with the engineering problem as they might be, were now being used. If the installation to which he had referred was pumping oil on a 12-inch line, it would be equivalent to pumping 400 tons an hour 20 miles, indicating that high-lift centrifugal pumps were not as much in their infancy as some people imagined. If the author could give any further information on the point of whether installations existed where high-lift pumps were being used, he would be exceedingly grateful, as he thought the high-lift pump was not receiving the attention from the oil world that it deserved.

Mr. N. A. Anfilogoff said that for the same reason that the members were deprived of listening to some of the author's recent experiences on the subject dealt with in the paper, he (the speaker) was also prohibited from mentioning some of his own experiences, but he desired to refer to a few of the technical points that had been raised in the paper. With regard to the foundations, he thought piles, whatever the ground might be, were most dangerous to use, unless they were made of ferro-concrete, and were capped by a ferro-concrete raft. In at least one case of which he was aware, the ground was piled a considerable number of years ago, and those connected with the work had forgotten all about it until one morning, on arriving at the works, they found a lot of oil would have to be

dealt with in the enclosure, because one of the piles which had not rotted away had poked its head completely through the bottom of the tank.

He did not know the particular case to which the author had referred in connection with the Z-bar construction of the bottom. Good reasons might have existed in that case for the adoption of such a method, but it could not be used for storing acid or acidified oils. He could not see that any worse results would be obtained if a plain straight plate was used at the bottom than if a Z-bar was used. Moreover, if the tank was not fixed up on a specially-prepared ferro-concrete raft which was designed to carry the exact weight on every foot of its area, the chances were that it would become a cupola, and the bottom would break. On ground with which he was acquainted, which could only stand a weight of about 10 cwt. to the square foot, and which was mostly overloaded to the extent of 120 per cent., he was afraid anything outside the ordinary fairly thick bottom would cause a lot of trouble. Petroleum engineers, however, were quite used to that, because if they had not a tank to lift up every now and again they suffered from ennui.

With reference to the author's remarks with regard to the testing of tanks, in small tanks, if a leak was noticed it could be marked, caulked, filled up again, and tested. In larger installations, unless the tank was caulked while it was full, the seams on one side or the other of the leak were opened up, and it was only by caulking when the tank was full that it could be made tight.

The author had referred to a diver being sent down into a tank containing 30 feet of oil. Personally, he was afraid he would have been discharged if he had done such a thing, and he could not see any reason for doing so except for the sake of an experiment to ascertain how long the diver's suit would last. The tank might just as well have been emptied without the swing-pipe, until there were only two or three feet of oil in the tank. He would guarantee to empty a tank completely without any swing-pipe at all, even if the valve was about three feet above the bottom. With regard to the pipe-connections and the elbows on the suction-pipes of the tanks, he thought that a packed socket was worse on a swing-suction inside of a tank than on a pipe-line outside. Under those circumstances one could at least see when the socket leaked. On the inside of the tank, especially when petrol was being stored, the packing dried up, and leaks occurred, and when the spirit was below the level of the swing-suction, trouble was experienced in emptying the tank. In those cases even a diver could not help.

It was also bad practice, in his opinion, to have elbows on the outside of the tanks; first of all because they introduced leaks in the suction, and secondly, so far as petrol was concerned, he did not think elbows would remain movable except for two or three days: they rusted up. The only method of connecting up to the pipe-line from the tank if the ground was bad was by means of a flexible connection which could be removed after the tank had found its bottom.

He had had 20 years' experience of the heating of pipe-lines, and, in his opinion, the only reasonable way of carrying that out was by means of an internal steam-pipe. By that means direct heating was obtained. Personally, he would not adopt the method which the author mentioned. An internal steam-pipe of more than two inches diameter was never used. Seeing that all pipes of two inches and downwards were butt-welded and not lap-welded, the chances were that with expansion and contraction, expansion particularly, the steam-pipe would split. Personally, he never used more than a one-inch pipe, and obtained quite good results in that way, but the pipe was solid-drawn. An interesting point in that connection was that, as the members were well aware, most of the pipes that were sold at the present day had a thread which was slightly tapered. The thread on the socket which was supplied with it was parallel, and if it was exaggerated in the mind's eye it would be noticed that the only way in which it could be hoped to keep the socket and pipe tight was by jamming up the last thread on the pipe. In that way, immediately a movement was obtained inside the pipe, the joint was broken, and leakage resulted. Although the makers had fought shy of carrying out his instructions, he had insisted that all the sockets supplied with pipes that he required, especially for steam-pipes and for internal steam-pipes in oil-lines, should have sockets with the thread tapered both ways, in exactly the same ratio as the taper on the pipe itself. In some of the long lengths of pipe, an expansion of 2 feet 6 inches or 3 feet was obtained on the inside steam-pipe, and some means must be provided for that expansion. Personally, he used packed glands at the end where the steam-pipe was allowed to go in and out.

The author had deprecated the use of expansion-joints on pipe lines. He believed in that connection the author was only referring to pipe-lines of moderate size. For hot pipe-lines he was afraid an easy bend here and there would give a lot of trouble, and that the requisite expansion would not be obtained. It was impossible to have loop bends on a heated line because of the difficulty of putting the steam-pipe through it, and in that case he thought the author

would agree that some type of expansion-joint must be provided, either of the packed type or otherwise, which gave a straight passage.

The author mentioned that, for pumping spirit, air should be used. He did not know whether the author had actually designed such a plant, and had seen what happened under those circumstances. Personally he had. Some years ago one of the boilers had to be shut down, and he had quite a lot of work to do at the other end of the Works, and, as he always had compressed air on tap, he used that compressed air with a pump similar to the one recommended by the author, an ordinary duplex Worthington pump. It was quite likely that if the work had taken only a few minutes to do, things would have been all right, but, having a large amount of pumping to perform, it was found that every 20 or 30 minutes the pump had to be stopped to enable him to clear the ice from the exhaust, because, naturally, as the compressed air came out and expanded, it froze everything up. He did not know if that difficulty could be overcome; probably the raising of the temperature of the air would get over the trouble; but he could not see, from the engineer's point of view, what advantage was gained by following the author's suggestion. If it was in a small works, where the local Council provided the current, it might not be quite so bad. He knew of one Council which practically gave their current away so, that the scale of rebates worked out that if only the consumer used sufficient current the Council owed him something. In large works, which had to provide their own current, by the time the heat given off from the coal was converted into steam, that steam had driven a dynamo or an engine, the dynamo had provided the current, and allowance was made for the losses from the dynamo to the motor, from the motor to the air-pump, and from the air-pump to the pump, he thought the mechanical efficiency must have dropped down to very nearly the same freezing point as it did on the exhaust. He had had quite a large experience of pumping with air, and for choice he would not adopt that method. If it was intended to warm the air, it was necessary to have steam, and, as they must have steam under any conditions, they might just as well use steam on the pump as air. In connection with that, the author mentioned that if air was used the man in charge could stand in the canning shed, watch his gauge-glass, and shut the valve when necessary. Personally, he suggested that by fixing a relief-valve on the pump itself he could shut the inlet into the tank, and need not touch the air-valve or steam-valve.

The author mentioned that heating oil in special tanks was an advantage in storages that dealt with lubricating oils. In that

respect he thought the author was harking back to the old days when Russian oil was brought over which was rather sensitive to moisture, and the little moisture which made it cloudy could easily be driven off by heating and blowing the oil up with a little air. Latterly the oil that had come over from Russia was, in the first place, alkaline, and, in the second place, it contained a considerable amount of sulphate of soda and "soda glut" in suspension, so that heating and blowing the Russian oil with air was not successful. American oils were now being imported which went absolutely black if the slightest heat was applied to them, and one dare hardly breathe near some of the Galician oils for fear of discolouring them; so that he was afraid that if reliance was placed on the heating of the tanks alone, and other means were not provided for clarifying the oil, the results would not be satisfactory.

Dealing with another point raised in the paper, in his opinion the blending of oils by air might be quite feasible in cases in which pure mineral oils were concerned, but it must be remembered that vegetable oils or animal oils which were blended with mineral oils, especially rape oil, which was generally used, thickened with air. The rape oil dropped down to the bottom immediately the air was stopped, and it would not be blended, so that it was advisable to save oneself the trouble of doing what the author had suggested.

Mr. Alexander MacDougall in the first place desired to add his tribute of praise to the very able survey the author had given of the oil industry. He had touched in one part of the paper upon the question of the foundations most suitable for large oil storage tanks. Personally he had had a great number of years' experience in the erection of oil installations "somewhere in Great Britain," and his last experience was of a very trying character. Oil engineers could not always choose the sites for the tanks they had to erect; he wished they could. The question of the sites of the tanks was governed by the depth of water in the particular port or river upon which the installations had to be erected. In the instance to which he referred, the whole of the docks were constructed by forming what might be best described as a circular breakwater, and then, by means of blowers (which, alas, he understood were of German make), conveying liquid mud from the river into the middle; and it was upon 40 feet of such liquid mud that he had to place the oil tanks. In view of his past experience and also the experience of other engineers, it was needless for him to say that he went to work with a somewhat quaking feeling, particularly as he found, on making tests, that at ten inches below the surface the mud simply ran through his hands, and that piling was

out of the question. Indeed, he quite agreed with the last speaker that piling was a very objectionable method.

He decided to drop large blocks of stone into this 40-feet deep mud, and, as some of the audience were aware, the tanks, when filled, settled down quite evenly, and to no great depth. He was averse to the use of concrete, piling, and all manner of expensive methods, if it was possible to deal with the problem in another way.

The foundations were always of importance, but he did not agree with the author that the surface should be broken. Personally, he thought it should be left alone, except for being strengthened.

He looked upon lightning conductors as utterly useless, and therefore he never used them. The tank itself was quite good enough.

He had dipped as many tanks as most people, and the result of his experience was most hearty agreement with what had been said about the necessity of hand-rails upon the roofs of tanks.

Mr. R. Marshall called attention to the fact that on an early page of the paper, the author, in dealing with the cubic capacity of the storage enclosure, suggested that it should be not less than 5 per cent. above the total capacity of the tankage erected within it. Personally, he was not sure whether there was any case on record of the whole of the tankage of an installation enclosure collapsing or being destroyed, but he suggested the figure the author had given was rather excessive. In view of the costly nature of the retaining walls or embankments, and of the land required for building them on, he thought a less quantity than 5 per cent. would be reasonable, and he suggested that 75 per cent. of the total capacity of the tanks would provide for all reasonable contingencies.

In dealing with tank foundations, the author suggested that "On hard rock foundations a layer of wood is also a useful precaution against damage to rivet-heads." He suggested that wood was rather an uncertain material to put under tank-bottoms. If a rock foundation existed, he put it to the author whether six inches of sand would not answer the purpose equally well?

He was glad to see that the very important question of lightning conductors had been ventilated, especially bearing in mind the requirements of insurance companies and local authorities. He had one case in mind where the local authorities insisted upon the provision of a lightning conductor in connection with underground petrol storage-tanks. Although the storage-tanks were underground, the local inspector required that a flagstaff arrangement should be erected with a lightning conductor on the top of it, and this in

spite of the fact that close at hand there were some high buildings and tall chimney-stacks efficiently equipped with lightning conductors.

A gas-holder in connection with the storage of petroleum spirit was rather a costly adjunct to the installation, but, on the whole, he suggested it was a desirable one, especially in a district where the local authorities were rather uneasy, owing to the nature of the installation. It certainly conveyed to their minds a great element of safety.

Objection was raised to the internal drop-valves which the author mentioned in connection with the foot-valves and the swing-pipes. He was acquainted with tanks which had been fitted with gunmetal vertical slide-valves on the inside of the delivery orifice, although he thought it was possible that the faces might get strained if there was any movement of the sides of the tanks. With regard to the connection of pipes to the bottom of the tanks, in some cases tanks were used with three or four inches of water at the bottom. Occasionally oil was discharged into tanks from the ship, and he thought if a comparatively small $2\frac{1}{2}$-inch draw-off pipe and valve were fitted underneath in a brick-enclosed valve-chamber that might be permissible.

With regard to the type of pumps used, the only objection he had to offer to the 3-throw geared power-driven pump was, in the larger sizes, the difficulty of keeping the glands tight, especially if thin oil or petrol were being dealt with.

So far as jointing material was concerned, the engineer was limited to a choice of very few articles, and at times it was rather difficult to know what was the best material to use. On the whole, he thought that compressed paper, with a coating of shellac varnish, made the cheapest and most efficient jointing material.

With regard to the question of the construction of the pipe-lines and the use of steel pipes, he would like to ask the author to what thread he recommended the pipe should be screwed. Did he recommend the coarse thread of 8 per inch, or the fine thread, English standard, 11 per inch?

In dealing with petrol storage, the author said that the storage-tanks should be buried in a horizontal position below the surface, and covered with concrete. He was not sure whether the author meant to convey that the whole tank should be embedded in concrete or that only a layer of concrete should be put on the top. Personally, he suggested it was not desirable to embed tanks in concrete.

The author further stated: "It is necessary to lay all piping

underground in concrete trenches filled in with sand covered by a half-inch layer of cement, and this again covered by iron chequer-plate." Personally, he did not appreciate the advantage of the thin layer of cement unless it was intended to keep out water, and he suggested the use of hard wood, such as teak, in preference to iron chequer-plate, which plate might be struck by metal falling on it and producing sparks.

He was much pleased to notice that in the last paragraph of the paper the author called attention to the perfectly safe way in which a storage-tank which had unfortunately become ignited burnt out. The remarks the author made in that connection should, he thought, carry great weight with local authorities, who unfortunately hampered the construction of oil-storages throughout the country with many drastic and very often unnecessary regulations.

Mr. A. Duckham said he had been much interested in the Zeppelin oil tankers which the author had described, and thought it would be of interest if an idea could be given of the weight that was necessary to pull a 5,000-ton tanker of that type at the rate of 10 knots. He would also like to know whether such tankers gave much trouble in steering. It occurred to him that they would steer well across the ocean, but that when the mouth of a river, such as the Thames, was reached, trouble might occur. He understood that no device was provided on the tanker for actuating steering.

Mr. Herbert Barringer, in reply, said he was much interested to hear what Mr. Dalley said with reference to the use of centrifugal pumps. Personally, he had never used such pumps with oil, one reason being that he had always doubted their capacity for draining out well. For continuous pumping he thought it was very possible that something was to be said in favour of the centrifugal pump, but when the deliveries varied considerably he had always understood that it was a little difficult to use a centrifugal pump, because if it was not run at its proper capacity, but at either above or below, it immediately became inefficient.

Reference had been made to the thickness of the bottom of the tank. Personally he would like to have it $\frac{3}{8}$ in. thick for the sake of durability. The foundation was generally the most expensive thing that had to be borne in mind; the foundation must be correct, and theoretically the bottom could be any thickness to contain the oil. The thickness of the bottom could not be relied upon to help much from the point of view of the foundation. Mr. Anfilogoff had referred to the statements made in the paper with regard to piling. He (the author) had only mentioned that as one of the systems which had been carried out. He did not know that he would be

inclined to adopt that system except under very exceptional circumstances, in which case he would probably leave the heads of the piles exposed, so that they could be examined, because he was afraid the piles sometimes did get into a very rotten state. Mr. Anfilogoff did not say how many centuries the piles to which he referred had been in use, but personally he knew piles would last for a very long time under proper conditions.

With reference to the question of caulking, he had always found that with water in between the sheets it was impossible to get a solid blow on the caulking, such as was possible if there was no water at all there. It was necessary to caulk for a reasonable distance above and below the spot marked as leaking.

He also simply mentioned the elbows as one of the systems which had been employed, not saying that he would adopt them himself at the present time. They had been employed with success in certain positions.

The great objection to the carrying of the steam-pipe through the centre of the delivery pipe was the danger of a breakage of the inner pipe, a danger which, if proper precautions were taken, might possibly be obviated. At any rate, some arrangement could be made in the main pipe-line by the insertion of a joint, so that if a break occurred it could be got at without breaking up a lot of the pipe-line, which was the expensive part of the work.

Mr. Anfilogoff had raised the question of socket-joints. Personally he was not thinking at the time of hot oil, but of oil at ordinary temperature. If the oil were heated to a temperature of 140°, the expansion became a very serious question, and must be properly taken up. It could not be dealt with by an ordinary loop-joint; the lines must be kept straight, and proper means be adopted with that object in view.

Mr. Anfilogoff had also referred to the use of air power. He (the author) had designed an installation which, so far as he knew, had been working very well ever since. Mr. Anfilogoff also asked why steam was not used. In the particular case to which he had just referred he was not allowed to use steam, which was a very good answer to the question.

Mr. MacDougall had dealt with the question of the foundations. When he (the author) mentioned moving the soil he did not intend to suggest that it should be moved to any depth; he only meant that the last year's crop of nettles should be cleared off. The remarks Mr. MacDougall had made with regard to mud foundations had emphasised what difficulties it was possible to combat even by studying analogies presented by a very different fluid.

With regard to Mr. Marshall's criticisms, the 5 per cent. allowed for the containing walls was the usual practice, and he believed in some districts it was the requirement of the local authorities. That figure had grown up as a sort of allowance that should be made, but he did not think it was at all necessary himself.

For tanks on rock-floors, a layer of sand would no doubt do just as well as wood, and possibly it would be better, provided there was no fear of its being washed out.

As for pump-glands, he did not know why those of a 3-throw pump were more difficult to keep tight than of a duplex pump. (**Mr. Marshall,** interposing, said they had larger plungers.) **Mr. Barringer** replied that he was not referring to a plunger pump; a double-acting three-throw pump could be used.

Mr. Duckham had asked a question with reference to towing. He calculated, according to the model exhibited, that a vessel having a dead weight of 6,400 tons would require a pull of about 13 tons to tow her at 10 knots. No means were provided for steering her at all, but the deep fin at the back was supposed to keep her on a straight line. She was towed with a bridle, and the resistance forward to any lateral movement was very slight. He hoped that all the movement would take place forward and that she would follow a straight line something in the same way that a barge did. The fin would act, he hoped, like the feather on an arrow, to keep her straight. (**A Member** asked why the bridle could not actuate a rudder at the rear which would compensate for the forward movement.) **Mr. Barringer** said he was afraid that would not be feasible with 250 fathoms of tow-line and a bridle, in the middle of the Atlantic. There were no doubt difficulties connected with its navigation in enclosed waters. There the tow-line would be brought up very much shorter, and when she came into really narrow waters she would be taken in charge by a tug. For instance, the "Navaho" was dropped at the Nore, and two tugs took charge of her. It was purely a commercial matter, and one of extra towage.

If an extra 6,000 tons could be brought across the Atlantic with only eight or nine days' loss of time occasioned by the towage, it must pay well. It remained to be seen how such a vessel would behave, but, personally, he thought the only danger that had to be faced was the loss of the ship through the breakage of the tow-line, which ought, however, not to occur. There was a factor of safety in buoyancy of 1 in 10, and 350 fathoms of tow-line could be used if required. A special towing winch was provided which automatically paid out and picked up the tow-line according to the strain on it. (**Mr. Duckham** enquired if there would not be a

tendency for the vessel to go down under water under the strain of the towing.) **Mr. Barringer** said that, in his opinion, the tanker would go through it, and even if she did go under water, he hoped she would come up again. There was 10 per cent. of buoyancy on the craft. (**Mr. MacDougall** thought that if the tow-rope broke, the tanker would become a danger to shipping generally.) **Mr. Barringer** thought she would float about; she would not make any leeway. (**Mr. MacDougall** asked whether it was not possible to devise an automatic arrangement, so that if the tow-rope broke an electric light appeared on the mast.) **Mr. Barringer** replied that the vessel would always carry lights constantly burning throughout the voyage.

On the motion of **The President**, a hearty vote of thanks was accorded to Mr. Barringer for his interesting and instructive paper.

At the close of the meeting, various appliances used in the measurement of oil in storage-tanks were shown, and **A. G. V. Berry** gave a demonstration of the action of the Redwood and Barringer water-finder.

The subjoined figure, one of the illustrations of the article on the Viscosity of Oils, by Dr. R. T. Glazebrook and his colleagues, was crowded out of our last issue, see p. 84.

Ed.

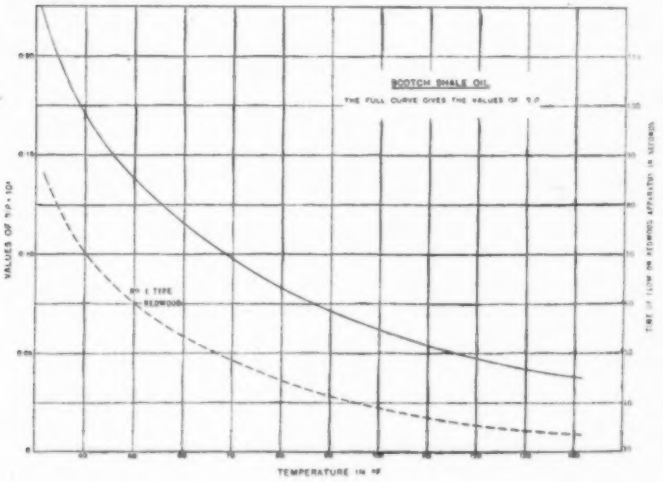

Fig. 30.